United States
Department of
Agriculture

Soil
Conservation
Service

Spokane
Washington

ECOLOGICAL INVESTIGATIONS ON THE TUCANNON RIVER WASHINGTON

245 00

ECOLOGICAL INVESTIGATIONS

ON THE TUCANNON RIVER,

WASHINGTON

Prepared for H. Esmaili & Associates, Inc.

Berkeley, California

April 1982

by

D. W. Kelley & Associates,

P. O. Box 634, Newcastle, California 95658

ACKNOWLEDGMENTS

The following persons provided valuable help to us on this project: Curtis Vail, Washington Department of Game; Ivan Lines, US Soil Conservation Service, Spokane; W. C. Fields, Jr. of Hydrozoology, Newcastle, California; Dr. Stanley V. Gregory, Oregon State University; Dr. T. C. Bjornn and Dr. Michael Falter of the University of Idaho; Barry Hecht of H. Esmaili & Associates; Fred Theurer, US Soil Conservation Service, attached to the Instream Flow Group, USF&WS, Ft. Collins, Colorado; Paul Rogers, US Soil Conservation Service; Bill Hubbard, Washington Department of Game; and, many ranchers and other citizens of the Tucannon River Valley.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

TABLE OF CONTENTS (cont.)

LIST OF TABLES

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF FIGURES

LIST OF FIGURES (cont.)

CHAPTER I. SUMMARY AND CONCLUSIONS

In October 1979 we were hired as subcontractors to H. Esmaili & Associates, Inc., of Berkeley, California, to conduct certain investigations on the biology of the Tucannon River in eastern Washington. These studies, which are reported here in our final report, are part of a larger investigation (by the US Soil Conservation Service) involving estimates of sediment contributions, and (by H. Esmaili & Associates, Inc.) of their transport and deposition.

Our major objective has been to investigate how land use practices in the Tucannon watershed have in the past and continue to influence the aquatic habitat on the Tucannon River. The importance of salmon and steelhead as a major public resource supported by the Tucannon River, once in much larger numbers than now, resulted in our spending a large proportion of our efforts assessing salmonid habitat needed for spawning, egg incubation, and rearing of juveniles. The study objectives, however, included assessment of other biota and of general stream health. To this end we investigated periphyton, aquatic invertebrates, and all of the fishes that live commonly in the river.

PERIPHYTON

We found periphyton communities abundant on the cobble bottom of the Tucannon River in all of the reach that we investigated. There was, of course, a great variation in its density even at the same station, and this variation was great enough to obscure any variations in total abundance from one reach of the river to the next. Our principal finding about periphyton that may be related to land use is that samples in the downstream reaches contained much higher percentages of inorganic matter. We suspect that is because of the periodic discharges of very fine sediment from Willow and Pataha Creeks into the Tucannon River. Such sediment is entrapped in the periphyton and may reduce its health or palatability to insects or other invertebrates. We found this difference only in July. By September it had disappeared.

AQUATIC INVERTEBRATES

Our collections of aquatic invertebrates from the Tucannon River were evidence that they are abundant and in

great variety. This abundance, along with good growth rates for the small fish, suggests that any shortage of food for young fish is unlikely.

Most of the invertebrates were those that feed on fine particulate organic matter which they collect as it drifts downstream. This trophic group made up 45 to 90% of the total numbers of invertebrates and were especially abundant at the lower stations.

Those invertebrates which shred larger organic matter, like leaves, were less abundant in the Tucannon River than we would expect from streams which receive more of their energy from leaf fall. Shredders were never abundant, but there were noticeably more at the upper stations than in the middle or lower reaches of the river.

Invertebrates that feed by scraping periphyton from rocks were the second most abundant group. There was a clear relationship between the density of their populations at the various stations during July and September, with the percent of the periphyton that had been organic matter in early summer. The populations of invertebrates that scrape rocks for a living may be influenced by fine sediment entering the Tucannon River from Pataha and Willow Creeks during winter and spring runoff. The significance of this is unknown and we have no reason to believe that a section of the stream with fewer scrapers is less "healthy".

SALMON AND STEELHEAD SPAWNING

We spent a considerable effort measuring the conditions for spawning and successful egg incubation throughout the main stem of the river.

We found that successful spawning and egg incubation on a regular basis, is limited to upper reaches well above Marengo. The risk of losing eggs because of both scour and sedimentation increases in a downstream direction, and below the mouth of Pataha Creek it is almost 100% with one notable exception. That notable exception is at the very mouth of the stream where loose gravel deposits have accumulated in the backwater of the reservoir to which the Tucannon is now tributary --a small run of fall spawning chinook salmon has become established or reestablished here.

FISH POPULATIONS

We were surprised to learn that the Tucannon River is too warm to rear significant numbers of juvenile salmon or steelhead, or to support many trout of any species in its lower 32 miles. We believe this is an unnatural condition and that it began with the reduction of shade from riparian vegetation during the large flood of 1964-65. The problem has been made worse by subsequent floods and continued channelization which minimize shade.

In the upper and cooler reaches, the salmon and steelhead populations were as dense as one might expect in fully seeded high quality salmon and steelhead streams. Growth was rapid and the fish appeared in good condition.

We found very few salmonids large enough to support angling anywhere in the river--a condition that we suspect is a combination of the heavy use for rearing juvenile salmon and steelhead, the extreme lack of pools, and the high stream velocities.

Besides salmon and steelhead, and Dolly Varden trout, the stream supports large populations of sculpins and fair numbers of longnose dace, speckled dace, redside shiner; and in its lower reaches, also squawfish and suckers. There is a run of lampreys.

Except for the lower two-thirds of the stream where the water temperature is too warm, juvenile salmonid rearing habitat is what we would term fair to good over most of the stream. By correlating measures of the quantity and quality of juvenile salmonid rearing habitat in different reaches of the stream with fish populations there, we estimated that under present conditions about 111,000 steelhead are reared past the middle of their second summer, and 170,000 chinook salmon are reared almost past the middle of their first. We believe that a program of restoring shade to the Tucannon River from Bridge 14 (River Mile 32) down to Pataha Creek would nearly double the number of young salmon and steelhead that could be reared.

There is also potential for additional rearing below Pataha Creek, but because of sediment contributions from that stream the problems below its mouth are somewhat more complex and less amenable to solution.

A program of creating pools in the upper area would increase the juvenile salmonid populations by about 50 fish per pool created.

CHAPTER II. THE STUDY AREA

The Tucannon River originates in the Umatilla National Forest area of the Blue Mountains of southeastern Washington at an elevation of 5400 feet above sea level, and flows over 50 miles in a northwesterly direction. It reaches the Snake River at an elevation of 500 feet above sea level (fig. 1) 63 miles above the confluence of the Snake and Columbia Rivers.

The annual precipitation on the watershed ranges from more than 40 inches in the higher elevations of the Blue Mountains to 10 to 15 inches at the lower elevations near the Snake River. Precipitation is light in midsummer, usually increasing in the fall, peaking in winter, gradually decreasing in spring, increasing again in June, and decreasing sharply in July. At lower elevations and in the farming areas, snow may be expected any time from late November through February. In the Tucannon Valley below 1500' elevation, snow seldom remains on the ground longer than three to four weeks or accumulates to a depth of more than 8-15 inches. Snow cover is sometimes melted very rapidly by a rain or "chinook" wind, and the runoff at such times may cause severe erosion. The one to three thunderstorms that can be expected from March through October often cause severe soil erosion (USSCS, 1973).

Air temperatures near the river (Dayton) average about 63° F. for the year. Average daily highs are near 90° F. in July and average lows below 40° F. in January. The differences between day and night temperatures can be as much as 40° F. in summer. The number of clear or only partially cloudy days increases from less than ten each month during the winter to more than 25 in midsummer (USSCS, 1973).

The Tucannon River drains approximately 510 square miles of land. It is fed by rainfall, springs, and melting snow. No large lakes or reservoirs regulate its discharge. The tributaries and the upper ten miles of river flow through the Umatilla National Forest. The next ten miles flow through the State Game Department's W. T. Wooten Game Range, which is also forested land. Between the Game Range and Marengo, a distance of 10 river miles, the drainage is used largely to range livestock. Between Marengo and the mouth of the Tucannon River, about 25 river miles, the land near the river is cultivated and used for livestock grazing.

There is a small amount of water diversion in the Tucannon Valley. Nearly all the land owners in the lower 30 miles of the river valley obtain water for summer irrigation

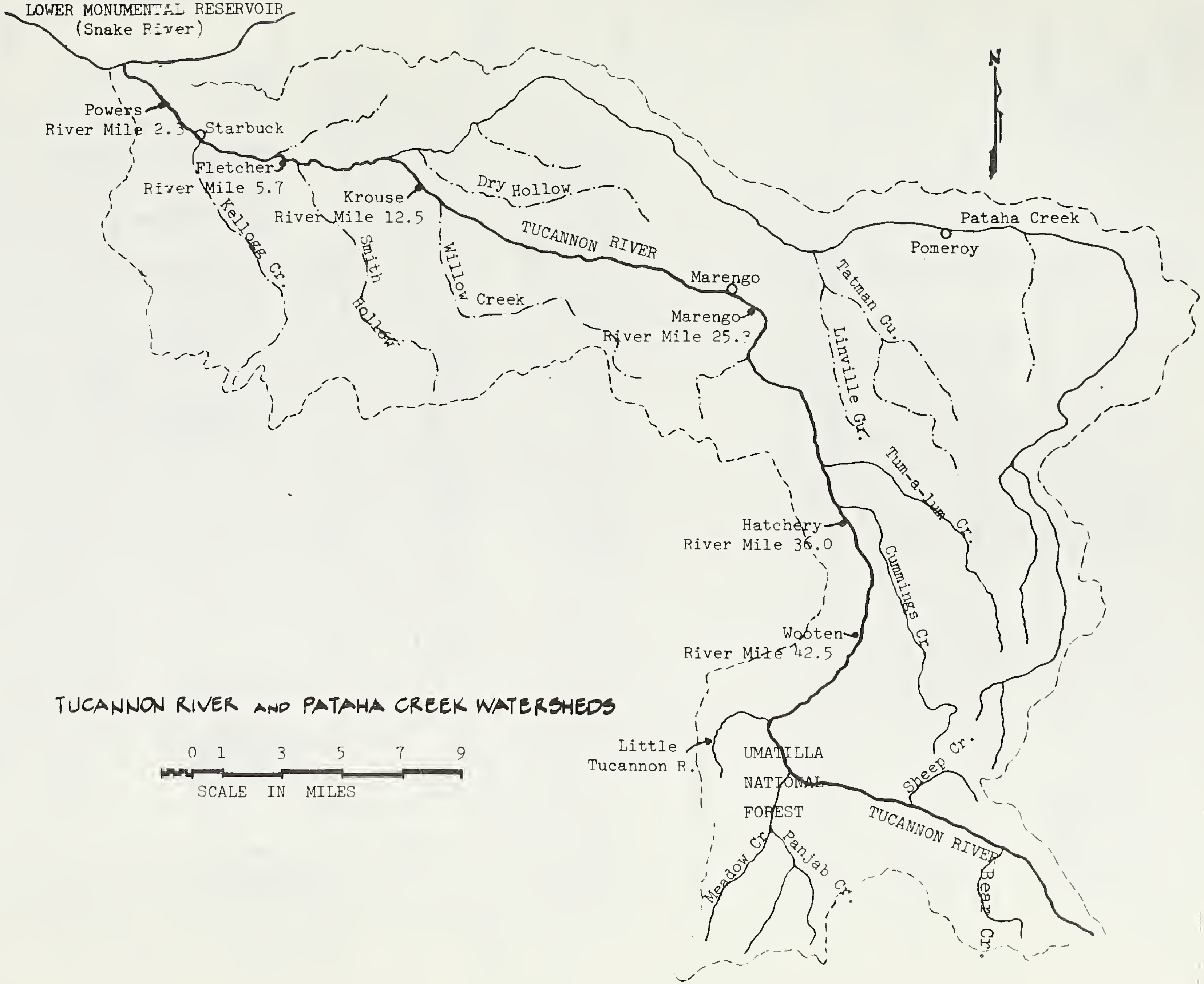


Figure 1. Map of the Tucannon River watershed.

either by constructing low wing dams in the river or by diverting from permanent low-head dams. After diversion, the water is pumped through sprinkler systems or is distributed to the fields by gravity flow through small ditches. These diversions are small and relatively few. They do not appear to diminish the flow in a way that is biologically significant.

Recreational opportunities of the Tucannon River watershed area attract increasing numbers of tourists and local residents annually. Most recreation is related to fishing, hunting, and camping. Fishing is particularly intense in the upper drainage where the State Department of Game owns and operates the W. T. Wooten Game Range, an area of about 11,000 acres. On the range are eight ponds, built shortly after World War II and designed to support a put-and-take rainbow trout program. Most of the fishing effort is directed at these ponds. The lower river is not heavily fished.

STREAM CHARACTER

The Tucannon River is fairly steep in the upper reaches, but gradually flattens throughout the remainder of its course (fig. 2). The backwater from Lower Monumental Dam has flooded the lower two miles. The width of the stream-bed varies from 20 feet in the upper river to about 60 feet near the mouth.

During the summer of 1980 biologist S. Li waded and made a number of physical measurements describing stream character in 18 reaches. He covered 16.6 river miles (fig. 3) or 31% of the river between its mouth and the confluence of Bear Creek and the Tucannon River. The measured reaches were interspersed to provide a representative sampling of the entire river below Bear Creek. Each pool, riffle, glide, or other kind of channel in these reaches was measured.

The section of the Tucannon that we measured carries a good flow through land that is easily eroded. Over 90% of the stream bottom is covered with medium and small basaltic cobble. There are few solid unerodible ledges and the few pools grade quickly into short glides and long, deep riffles.

In this report we defined pools as stream segments deeper than 1.5 feet with some constriction at the lower end of the segment. They represent only four percent of the stream's length and were especially rare in the upper reaches (table 1). The most commonly identified cause of pools was

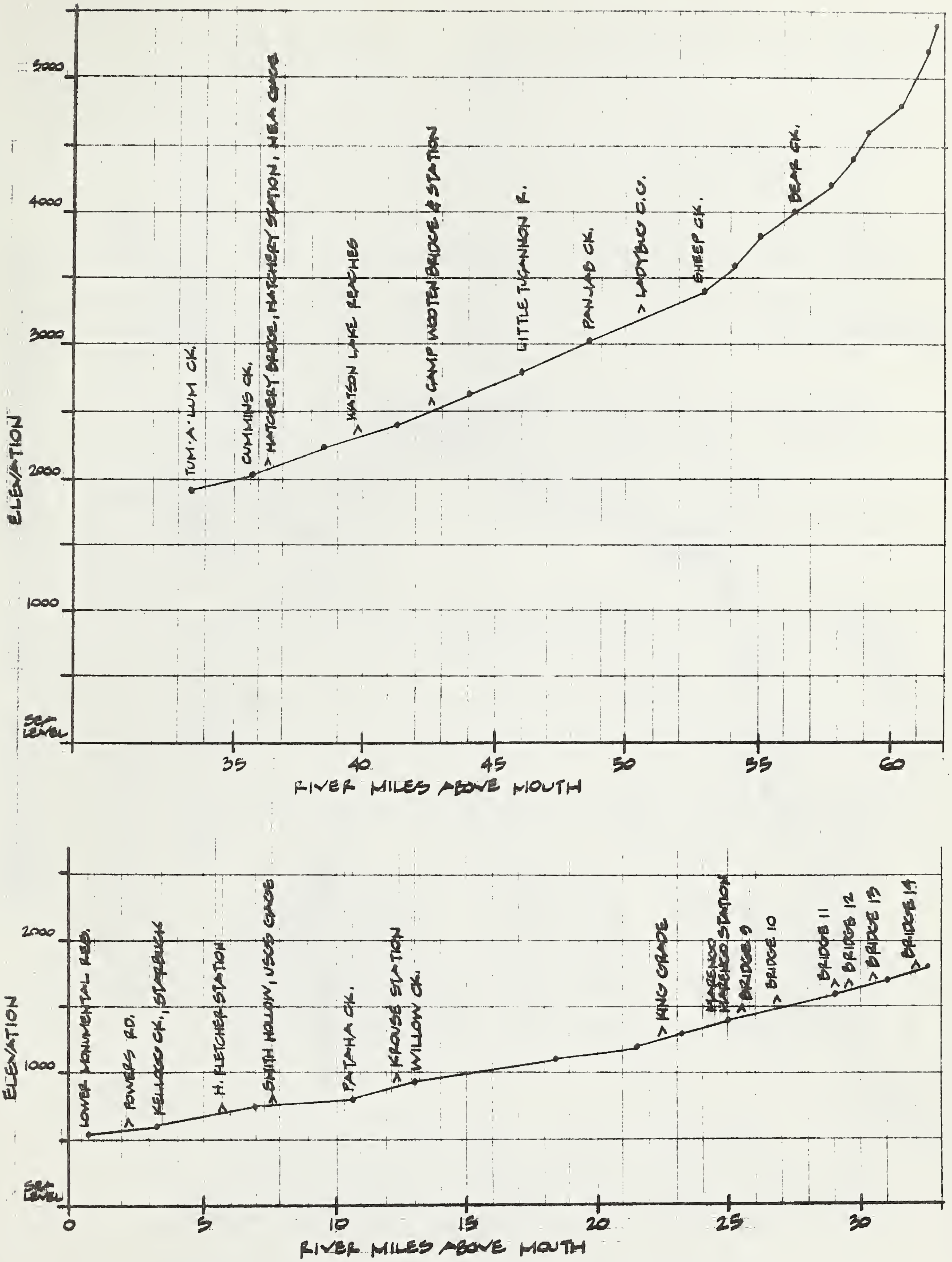


Figure 2. Profile of Tucannon River (USSCS Topo Map Analysis)

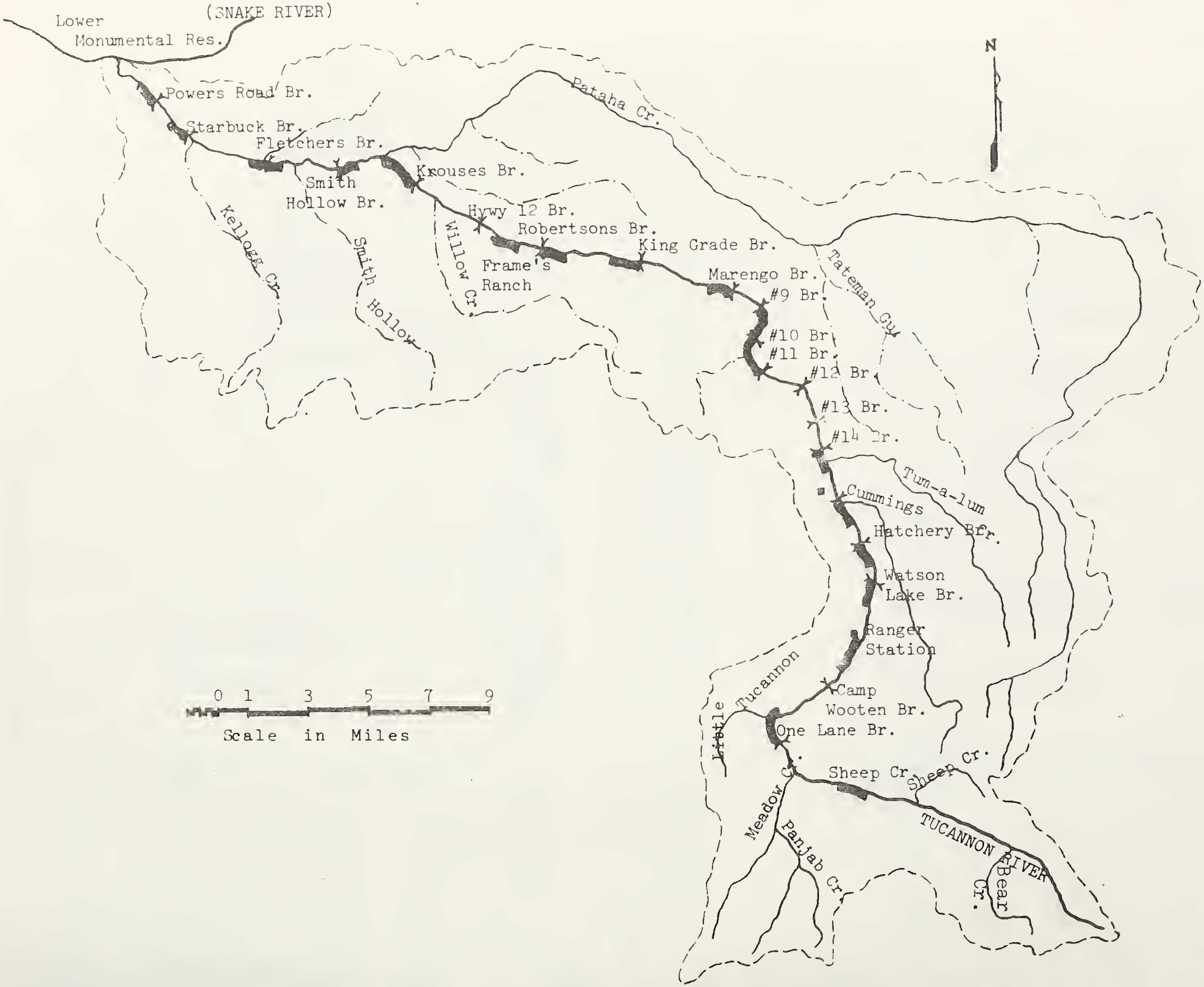


Figure 3. Location of 18 sections of the Tucannon River where stream characteristics and juvenile salmonid rearing habitat were measured in 1980.

Table 1. Physical characteristics of Tucannon River sections measured for fish habitat assessment in 1980.

MILES FROM MOUTH	NAME	LOCATION	LENGTH IN FEET	WIDTH IN FEET n. measure	WIDTH IN FEET aver.	CURRENT VELOCITY in feet/sec. n.measures	CURRENT VELOCITY in feet/sec. average	% of length in: POOLS	GLIDES	RIFFLES	OTHER
48.0	Sheep Creek	Lady Bug C. Gr. to lrg. pool.	2966	42	21.05	31	2.88	5.26	10.53	71.93	12.28
44.0	L. Tucannon	1 lane bridge to below confluence.	3677	43	27.74	40	2.88	5.80	14.49	63.77	15.94
41.8	Ranger Station	To 1st logjam below Tucannon CG bridge.	4189	48	25.53	39	2.92	1.72	14.56	70.47	13.25
39.8	Watson Lake	Bridge to riffle 12 up past W.L. pool.	3958	30	25.66	33	3.11	6.76	9.46	71.62	12.16
34.1	Hatchery	Hatchery Br. to above old channel	8033	60	25.15	63	3.05	0	12.93	62.59	24.49
31.7	Cummins Creek	Bridge to near hatchery.	6015	52	35.03	49	3.28	2.14	21.38	76.48	0
30.2	Bridge 14	Br.14 to Blind Grade turnoff.	5493	47	42.28	47	3.36	0	10.58	89.42	0
	UPPER RIVER		34,331		29.65		3.08	1.67	13.90	72.82	11.61
27.5	Bridge 10	Bridge 10-Bridge 11	8497	68	33.41	63	3.10	0.63	32.50	58.75	8.13
26.6	Bridge 9	Bridge 9-Bridge 10	6231	82	24.32	82	3.02	2.48	31.40	49.59	16.53
25.5	Marengo	Marengo Br. to mid-field blue sprinkler	4564	56	28.42	53	2.87	3.11	20.49	70.09	6.31
21.8	King Grade	K.G. Br. to 1st clearing.	5670	85	28.03	77	3.14	7.97	14.44	72.83	4.76
18.2	Robertson's	Br. to whirlpool.	5762	54	29.71	50	3.09	3.96	26.09	62.99	6.96
16.5	Frame's	Fallen tree pool to Derue line.	5593	66	29.03	58	3.33	12.26	32.80	48.11	6.60
	MIDDLE RIVER		36,317		29.12		3.09	4.73	27.02	59.86	8.40
12.0	Krouse's	K. Br. to old br. below Pataha Cr. confluence	9291	86	33.03	85	3.18	5.67	15.92	71.23	7.18
8.0	Smith Hollow	S.H. Br. to old cotton-wood stand.	5431	47	36.20	41	3.10	2.80	31.66	58.52	7.02
5.5	H. Fletcher's	Above dam down past dam and bridge.	6897	57	48.04	50	2.87	2.29	25.81	68.70	3.20
4.0	Starbuck	S. Br. to Little Goose turnoff.	5858	55	36.80	49	3.17	9.70	30.70	55.26	4.34
2.0	Powers	Tucannon Delta to Bridge.	5456	36	39.02	35	2.86	3.88	64.08	29.13	2.91
	LOWER RIVER		32,933		38.68		3.06	4.91	31.19	58.77	5.14
	RIVER TOTAL		103,581	1014	32.23	945	3.08	3.78	24.02	63.78	8.42

current redirected against erosion resistent substrate or logjams. The confluence of two braids also usually formed pools when the braids formed a "Y". Apparently, the joining of the two braids increased forces directed at the streambed to form the pool. Some pools were at the base of a gradient change. The stream flowing down the steeper gradient simply dug the substrate out when the gradient decreased. In two of the upper reaches, there were no pools at all. In both cases there was extensive human intervention. The banks of the Hatchery Reach and the Bridge 14 Reach had their banks riprapped, and Bridge 14 Reach was entirely channelized.

We defined riffles as any stream segment that included a significant amount of white water during the summer low flow period of 1980. Over 63% of the stream sampled was riffle. Most were over small cobble and gravel. Because this is easily movable substrate, these riffles were slowly migrating downstream, bouncing laterally from bank to bank. Many riffles changed the direction of streamflow so that banks were no longer parallel to streamflow. Many times the stream current ran directly into the bank.

We defined glides as stream segments less than 1.5 feet deep with no constriction at the lower end of the segment and no significant white water. About 25% of the length of the measured reaches were glides.

Other channels included side channels, bars, and trenches which did not fit the other categories and made up 8.4% of the stream measured. The stream was narrowest in the upper reaches and, except in channelized sections, gradually increased in width downstream (table 1). The unusual large width at Bridge 14 Reach is due to channelization of that reach. Twelve of the 18 reaches had significant portions of the banks altered and riprapped.

As part of the fish studies, Dr. Li measured surface current velocity using a Gurley Teledyne Pygmy Current Meter. In spite of a gradually reduced gradient the Tucannon River has very high stream current velocities throughout its length (table 1). The fastest reach was the channelized Bridge 14 Reach.

Because the streambed conditions are critical in assessing fish habitat, Dr. Li measured stream substrate on September 4-5, 1980. Within 50 feet of the upstream side of each bridge, he waded to the center of the river and sampled 10 rocks he could reach without moving his feet. He measured the length of each rock and estimated the degree to which it was embedded in sand expressed as a percentage of its height. The results indicate a strong trend for decreasing substrate

size in the downstream direction (fig.4), and an indication that embeddedness, the degree to which cobble is embedded in sand, may increase in the downstream direction (fig. 5).

The Tucannon River is, in places, a braided stream with water flowing down branching channels. We divided each section length by the number of braided places in each section as an index of braiding (table 2). The middle reaches of the river were braiding more.

Gravel migrating downstream from the steep upper reaches during high flows is evidently deposited in the flatter middle reaches below Bridge 10.

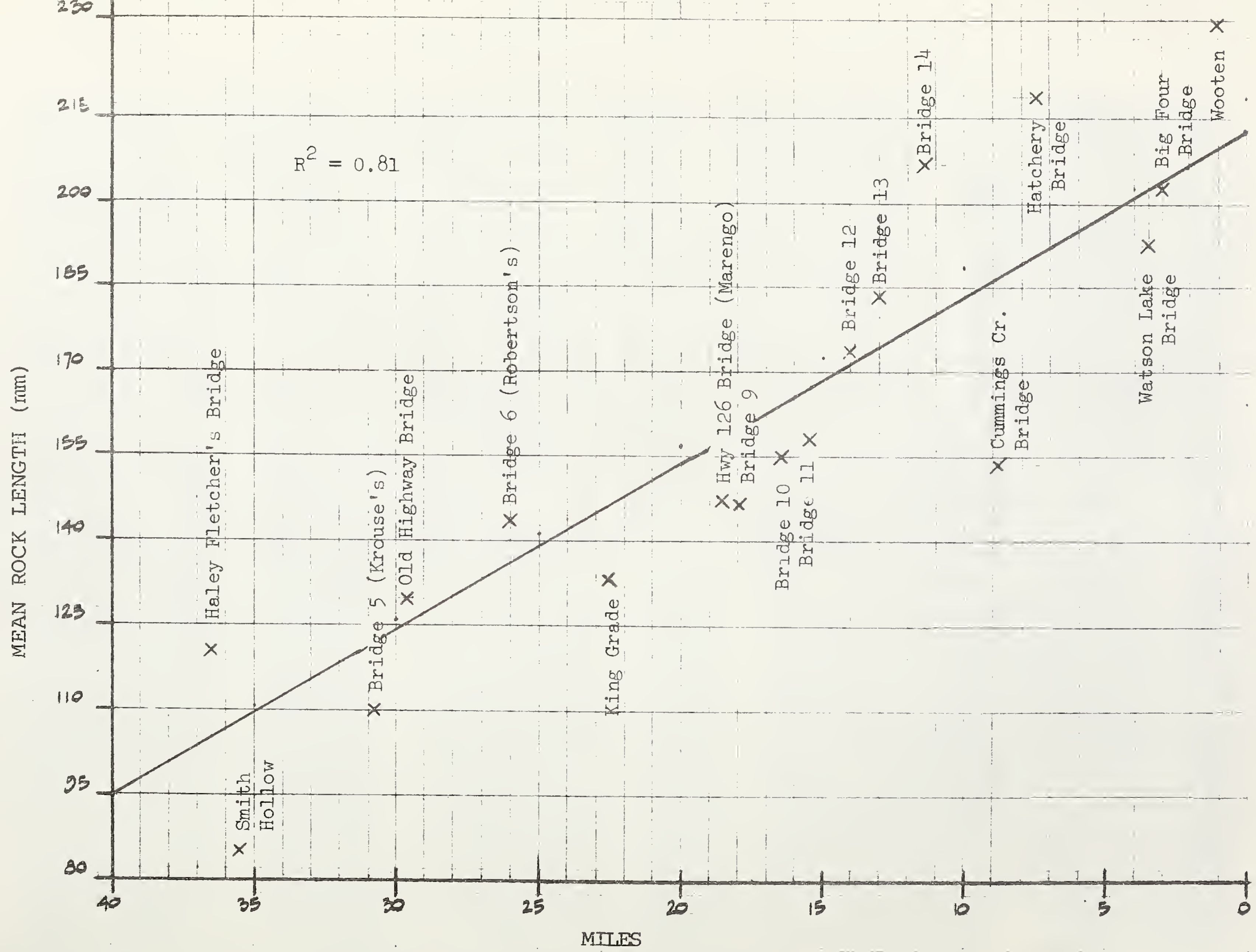


Figure 4. Relationship between bottom rock size and location in the Tucannon River, 1980

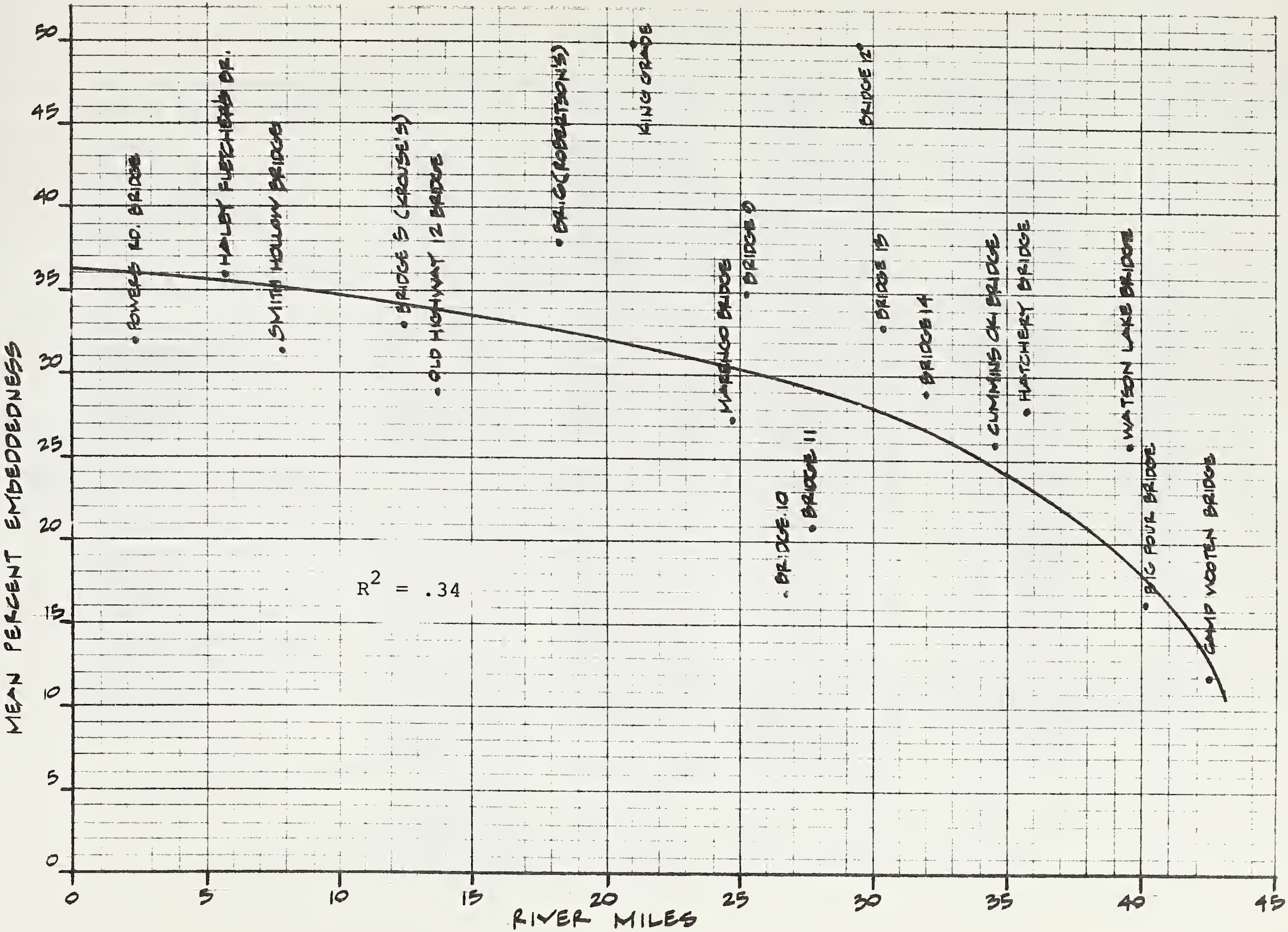


Figure 5. Increasing levels of cobble embeddedness in downstream direction.

Table 2. Rate of braiding in the Tucannon River, summer 1980. A lower number in column 5, indicates higher rate of braiding.

LOCATION	MILES FROM MOUTH	SECTION LENGTH(ft)	NUMBER OF BRAIDED SEGMENTS	RATE $\left(\frac{\text{length}}{\text{n. of braided segments}}\right)$
Sheep Creek	49.8	2403	3	801
L. Tucannon River	43.7	3084	3	1028
Ranger Station	41.8	3597	5	719
Watson Lake	39.9	3308	2	1654
Hatchery	35.9	5434	6	906
Cummins Creek	34.7	5810	4	1452
Bridge 14	32	5376	1	5376
Upper River Totals		29,012	24	1209
Bridge 10	26.9	6502	12	542
Bridge 9	25.2	4702	9	522
Marengo	24.8	3814	5	763
King Grade	21	4895	7	699
Robertson	18.2	4823	7	689
Frame's	16.5	4978	7	711
Middle River Totals		29,714	47	632
Krouse	12.5	7772	7	1110
Smith Hollow	7.9	4441	5	888
H. Fletcher	5.7	6719	2	3359
Starbuck	4.4	4700	4	1175
Powers	2.3	5306	1	5306
Lower River Totals		28,938	19	1523

CHAPTER III. INTRAGRAVEL ENVIRONMENT:CONDITIONS FOR SALMONID SPAWNING AND EGG SURVIVAL

Accelerated erosion often causes deposits of silt and sand in stream gravels to the levels that reduce the survival of salmonid eggs. Early in our investigations, Dr. Richard Armstrong reviewed literature on this subject. Following that, we began field measurements to define any such problems on the Tucannon River. Six study stations were selected.

The Camp Wooten Station at River Mile 42.5 was the highest reach investigated. This area was just upstream from the bridge crossing the Tucannon River to Camp Wooten and is within the Umatilla National Forest. There has been some logging in the drainage basin above that point, but the streambed consisted primarily of small boulder and cobble with almost no sand or silt, and not much gravel on the surface.

The Hatchery Station at River Mile 36.0 was just upstream from the road bridge going to the Washington Department of Game's Tucannon River Fish Hatchery. This station is within their game range and above any farmland. The river has been channelized and there is some erosion associated with the road in the immediate area upstream. The substrate was principally boulder and cobble with no significant amounts of sand and silt visible on the surface.

The Marengo Station at River Mile 25.3 was about one-half mile above Marengo, on the Emil Horvid Ranch in the middle reaches of the Tucannon River. The Tucannon River Valley floor above Marengo is both grazed and cultivated, and the surrounding hills are grazed. Substrate at Marengo was largely clean cobble and boulder.

The Krouse Station at River Mile 12.5 was downstream just above the junction of the Tucannon River and Pataha Creek and just below the bridge on the Otto Krouse Ranch. Often there was a noticeable increase in turbidity at the Krouse Station. The substrate was of smaller cobble and included more gravel. During the winter, there was an extensive and frequent gravel shifting here.

The Fletcher Station at River Mile 5.7 was downstream of Pataha Creek, just above the Tucannon River Bridge on the Haley Fletcher Ranch. Pataha and Smith Hollow Creeks contribute a significant amount of soil to the stream during storms. The substrate here was primarily cobble, with some gravel. There was no obvious deposition of sediment on the surface.

The Powers Road Station at River Mile 2.3 was the lowest reach where the intragravel environment was investigated. During the winter there was a considerable deposition of silt on the stream surface there, and in many places the bottom was so consolidated that digging simulated salmon nests was very difficult.

METHODS

Dr. Armstrong's review led us to believe that we should attempt to measure the concentrations of dissolved oxygen in the intragravel water and the rate of movement through the gravel. We began the first week in December, 1979, by installing five minipiezometers of the type described by Lee and Cherry (1978), and ten standpipes of the type described by McNeil (1962)(fig. 6) at all of the stations. The piezometers were buried in places selected by D. W. Kelley and S. Li as having the substrate, depth, and current velocity characteristics that would be attractive to spawning salmon or steelhead. Each piezometer was laid in the bottom of an excavation approximately 3 feet in diameter and 1.5 feet deep, made with a hoe in water between 0.9 and 1.5 feet deep, where surface current velocities ranged from 0.7 to 2 feet per second. The simulated nest was filled by digging upstream just as the salmon or steelhead would do and letting the gravel and cobble drift down into the excavation over the piezometer. At all stations, digging always released large amounts of fine soil that had been trapped in the substrate. All standpipes were driven to a depth of 10 inches below the gravel surface at similar stations.

As an indication of the probable loss of the salmonid eggs buried in nests because of streambed scour, we strung a series of four to seven Ping-Pong or styrofoam balls on 3 foot monofilament line, and buried them with an anchor at the bottom of the line, in a column. This method was developed by McNeil

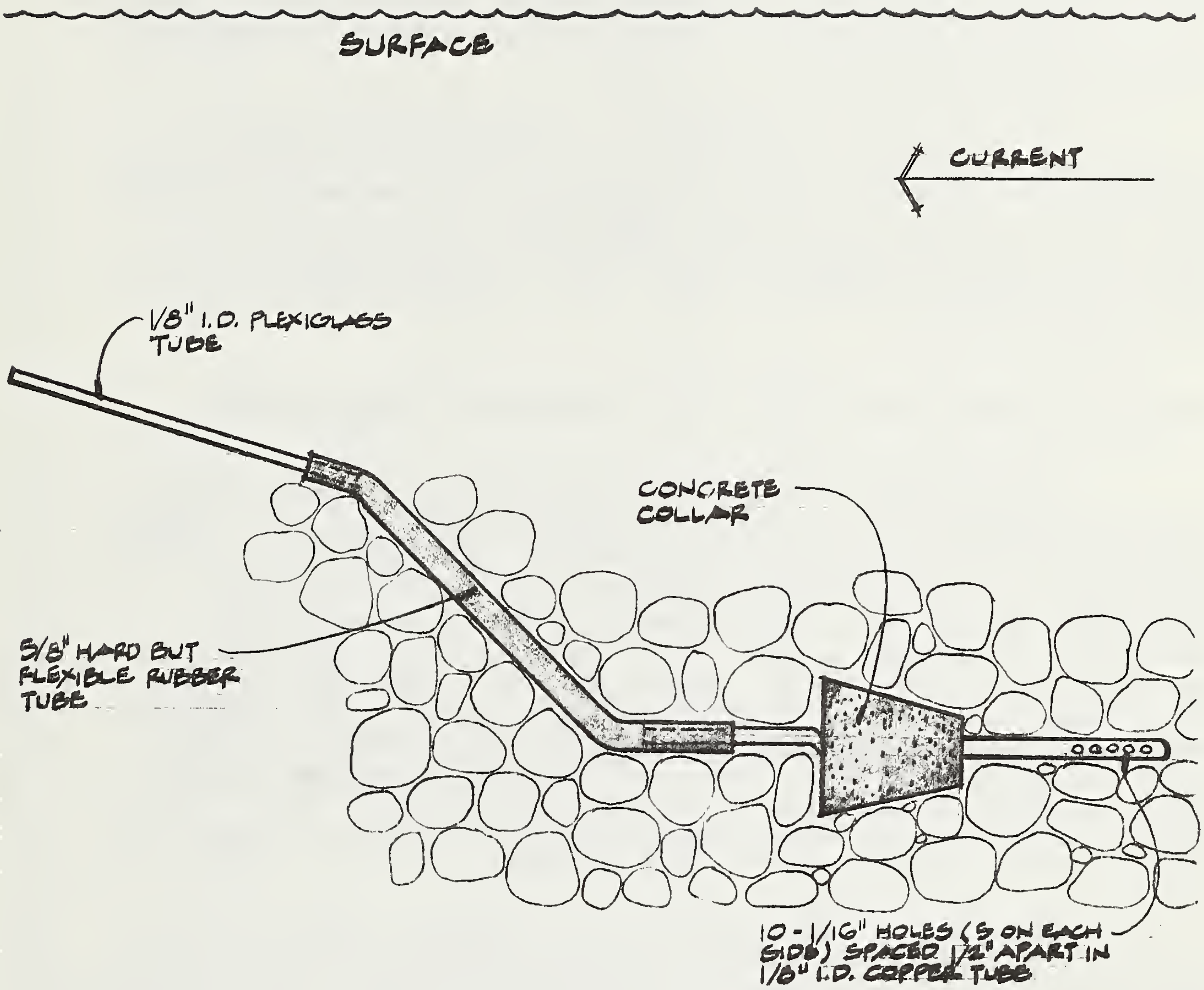


Figure 6. Minipiezometers used for studying intragravel water in the Tucannon River. Dixie cups were used to form the concrete collar. The rubber tube allowed the longer plexiglass tube to lay flat on the stream bottom and be raised for sampling intragravel water.

(1962) working on Alaskan streams. The idea is that, as the scour uncovers the balls, they float up to the end of the monofilament line which is held in place by the anchor. Most of our Ping-Pong balls were either washed away or covered up with moving substrate during storms.

All who have attempted to investigate intragravel conditions in western streams during the winter and spring periods have suffered major losses of their measuring devices and, thus, of potential data. Because of scour we were required to replace many piezometers and standpipes several times and finally abandoned the idea of using piezometers at the Powers Station.

HYDRAULIC CHARACTERISTICS OF THE INTRAGRAVEL ENVIRONMENT

We made four types of measurements to improve our understanding of flow in the intragravel environment. Three were made using the buried piezometers, and the other utilized standpipes. All measurements based on piezometers took advantage of the fact that in most of the piezometers we installed, there was a positive hydraulic head relative to the surface of the stream. Water at the bottom end of the piezometer was under pressure, so that water in the sampling tube leading to the buried piezometer was forced slightly above the stream surface when the tube was lifted above the stream surface. Because of this hydraulic head, there is a flow of water through the piezometer as long as the sampling tube is below the surface of the stream.

Dr. Armstrong measured the hydraulic head on individual piezometers with a simple manometer. The pattern of his observations suggested a tendency for the head to increase in a downstream direction (table 3), although measures at the Hatchery Station were "out of sequence". However, analysis of variance (ANOVA) on this data did not show any significant station effects unless the negative values (which may have been erroneous) were eliminated.

For the second kind of measurement, Dr. Armstrong attached a toy balloon to the sampling tube, submerged the ballon, and measured the amount of water running through the piezometer in a given length of time. The measure is related to the percolation rate described by Coble (1961) and earlier workers. Coble found it to be useless for explaining the variance in salmonid egg survival, but it is easily done and, in the beginning, seemed a useful measure to make.

Table 3 . Intragravel observations made with piezometers on the Tucannon River, Feb. 6-11, 1980.

	Piezo-meter	POWERS RD Riv.Mi. 2.3	FLETCHER Riv.Mi. 5.7	KROUSE Riv.Mi. 12.5	MARENGO Riv.Mi. 25.3	HATCHERY Riv.Mi. 36.0	WOOTEN Riv.Mi. 42.5
HYDRAULIC HEAD ON PIEZOMETER cm	A	1.43	1.59, 7.62	6.35, 3.49	5.08, 1.75	1.11, 2.86	2.06, 1.75
	B_1	.64	4.92, 5.08	4.44, 1.59	.95, 2.06	2.22, 1.59, 1.90, 1.90	1.11, .95
	C	16.19	---	-5.08	2.06 (B_4)	6.19, 4.76	4.13, 2.70
	D	-1.75	---	2.54	.32 (B_2)	2.86, 3.97	-12.38, .64
	E	6.35	2.22	2.06	1.75 (B_4)	2.06, 2.86	1.11, -.63
	$\bar{x}$	4.57	4.28	2.20	1.99	2.86	.14
	S	7.13	2.43	3.59	1.50	1.46	4.58
DISCHARGE THROUGH PIEZOMETER CM^3/hr	A	89	57	44	---	34	15
	B_1	200	73	38	5	33	90
	C	---	---	---	---	35	60
	D	---	---	66	---	42	---
	E	36	34	39	---	27	51
	$\bar{x}$	108	55	46	5	34	54
	S	83	19	14	---	2	30
HYDRAULIC CONDUCTIVITY K_H cm/sec x 10^3	A	2.23	1.28	.24	---	1.07	.26
	B_1	11.15	.52	.32	.18	.52	2.87
	C	---	---	---	---	.20	.51
	D	---	---	.92	---	.57	---
	E	.20	.54	.67	---	.46	1.63
	$\bar{x}$	4.53	.78	.54	.18	.56	1.32
	S	5.82	.43	.32	---	.31	1.20

Armstrong measures of daily discharge through the piezometers were not significantly different from one station to the next. The data is characterized largely by major variations at the same station.

The third measure of hydraulic characteriestics is a calculation using the percolation and the manometer data and some characteristics of the piezometer construction to calculate a term that Lee and Cherry (1978) named "hydraulic conductivity".

$$K_H = \frac{q \ln \left(L/D + \left([1 + L/D]^2 \right)^{\frac{1}{2}}\right)}{2\ L\ H_c}$$

where:

K_H = hydraulic conductivity

q = discharge into the ballon (cm^3/sec)

L = length of perforated portion of piezometer tube

D = diameter of piezometer tube

H_c = piezometer head

"Hydraulic conductivity" describes the "apparent velocity" of water moving through porous material as being proportional to the head which is causing the movement. When the hydraulic conductivity is high the water is alleged to move fast without being pushed very hard, if it is low, even a very high pressure will cause little movement.

Once again there was considerable variability between measurements made at the same station and analysis of variance that did not reveal any significant differences between stations. The hydraulic conductivities calculated with data from our measurements are similar to or approaching those normally found in clean, sandy gravel (Davis and DeWiest, 1966).

As his fourth measurement, Dr. Armstrong introduced salt into standpipes, and measuring the rate at which it traveled doswnstream to another standpipe fitted with a milliampmeter measured changes in electrical conductivity. Deflection of the milliampmeter was recorded at frequent intervals until the effect of the salt was no longer seen. The distance between the standpipe and the electrode was measured and this was divided by the length of the time required for the

salt to travel from the upper to the lower standpipe. The length of time used was the time lapse from placement of the salt in the upper standpipe until the needle of the milliampmeter reached the maximum deflection.

The measurement of apparent velocity of intragravel water measured by the flow of salt solutions downstream from standpipes appeared reasonably rapid (table 4). Once again there was great variance between samples.

DISSOLVED OXYGEN CONCENTRATIONS

The samples for DO measurement were taken from the piezometers by sucking a small amount of water out to clear the tube and ensure that the sample to be measured was intragravel and not above gravel water, and then withdrawing intragravel water from the redd itself into a 30 ml bottle when DO was measured with a YSI Model 57 probe.

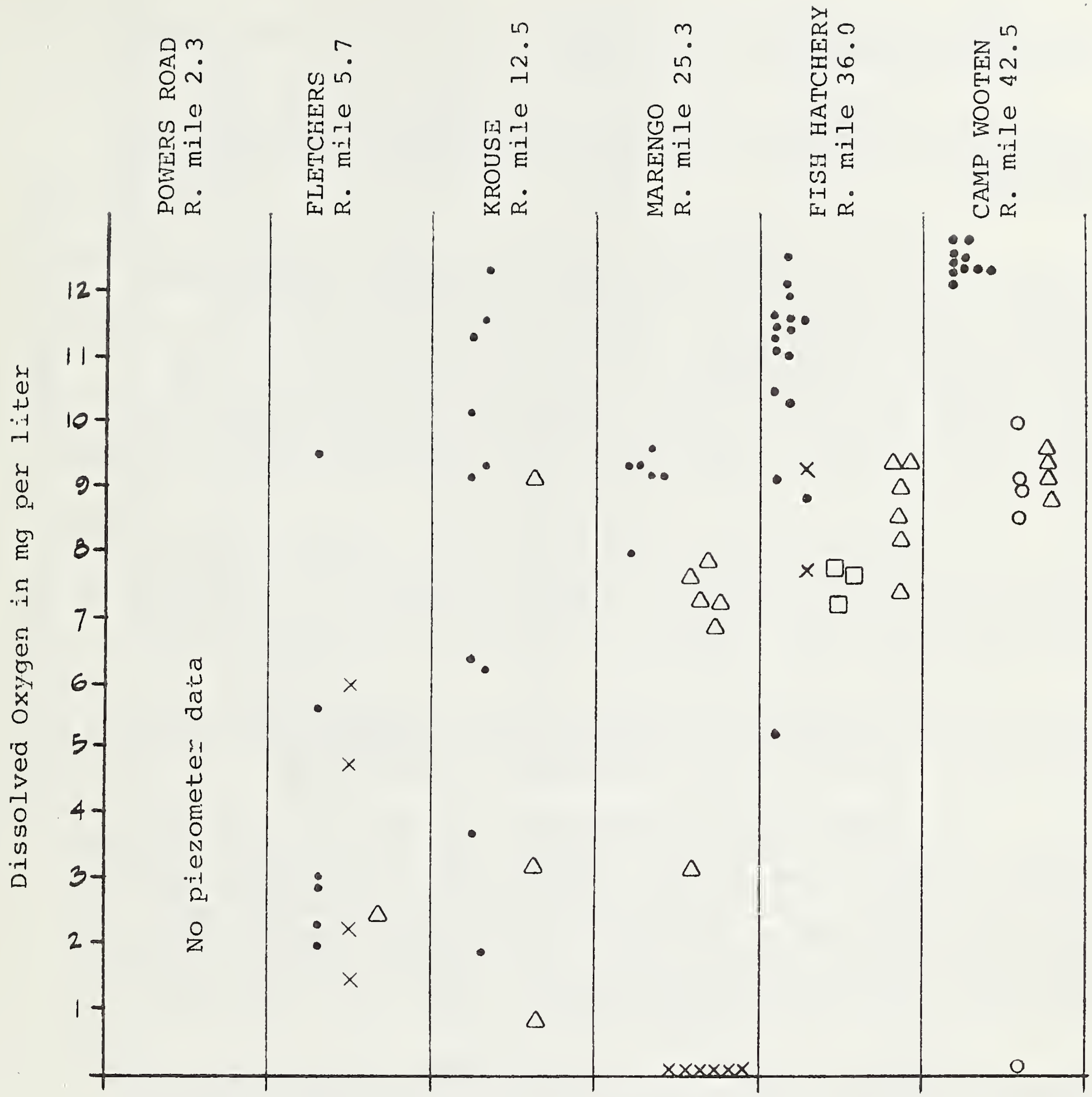
The dissolved oxygen measurements in the redds we built and in the undisturbed gravel outside of the redds measured with standpipes, provided much more useful information than did the measures of intragravel hydraulics. Piezometers and the standpipes were first buried on December 1, 2, and 3, 1979. Water temperatures at that time ranged between 2 and 3 degrees Centigrade, and DO concentrations were saturated at between 12 and 13 milligrams per liter. Measurements of dissolved oxygen in these redds were made periodically from then until June. By that time, some of the nests we built had been buried by moving cobble and gravel so that measurements during the winter produced a diminishing amount of data as spring approached. Even so, changes in dissolved oxygen concentrations in the simulated nests provided good evidence that, except for problems of scour, conditions for the hatching of salmon or steelhead eggs were excellent in the upper river and probably satisfactory down at least as far as Marengo (fig. 7).

Dissolved oxygen concentrations in the nests at Camp Wooten did not decline during the two months from when they were built to early February. At Wooten, all piezometers but one remained in place until we removed them in June. The dissolved oxygen concentrations in all of these simulated nests remained above 8 milligrams per liter for the entire four months.

At the Hatchery Station, dissolved oxygen concentrations in about half of the nests were reduced by a few milligrams per liter within the first two months and one was reduced to slightly above 5. All of the piezometers remained in place and none were buried by moving substrate. The DO concentrations

Table 4. Apparent velocity of the intragravel water as measured by the flow of salt solutions downstream from standpipes (in cm/hr).

	POWERS RD	FLETCHER	KROUSE	MARENGO	HATCHERY	WOOTEN
	106	448	157	102	46	2743
	190	1067	24	80	49	109
		57		62	211	
		86				
$\overline{X}$	148.	414.	90.	81.	102.	1426.
S	59.4	470	94.	20.	94.	1863.



• 7-9 FEB
× 28 MARCH
o 8 APRIL
□ 24 APRIL
△ 29 MAY-3 JUNE

Figure 7. Winter-spring concentrations of dissolved oxygen in simulated salmon nests constructed December 1-3, 1979, at 5 stations on the Tucannon River. Concentrations were 12-13 mg/l when nests were built.

in all but one remained above 7 milligrams per liter through the last measurements in late May.

At Marengo, the DO in simulated nests dropped several milligrams per liter during the first two months, but by the end of May was still close to or above 7, in all but one nest.

At Krouse Station, dissolved oxygen concentrations in the nests two months after they were built, varied from less than 2 to above 12 milligrams per liter. The data suggests that about half of nests built here would not have successfully hatched eggs. There is much shifting of the substrate at Krouse's during the winter and two of the piezometers were lost, either washed away or completely buried under gravel. Only one of the three original nests remaining at the end of May contained dissolved oxygen concentrations suitable for salmonid eggs.

At Fletcher's all but one of the simulated nests suffered a serious decline in dissolved oxygen concentration to less than 6 milligrams per liter in December and January. We believe that eggs buried in the gravel there would have had little chance for survival.

Our attempts to obtain similar information at the Powers Station failed. Piezometers were washed away or buried with such regularity that we abandoned the effort.

A second set of piezometers was buried - five at each of these same stations - between May 30 and June 3, 1980. A large thunder storm on June 16 buried the nests built at the Krouse Station and scoured those at the Fletcher's and Powers Stations away. Because the streamflows were rapidly declining and water temperatures were rising, efforts to obtain additional information on intragravel conditions were then postponed until the following winter.

Between November 18 and 21, 1980, we built five new simulated nests at four new stations from just above Pataha Creek to the very lower end of the Tucannon River. These stations were selected to provide us with additional information on the lower river where sedimentation appeared to cause low dissolved oxygen concentrations in the gravel.

The uppermost station was located 600 feet above Pataha Creek on Blaine Fletcher's Ranch. Dissolved oxygen concentrations in all five nests built there were at saturation level when the nests were built and remained so until the last measurement on December 18, one month later (fig. 8). On

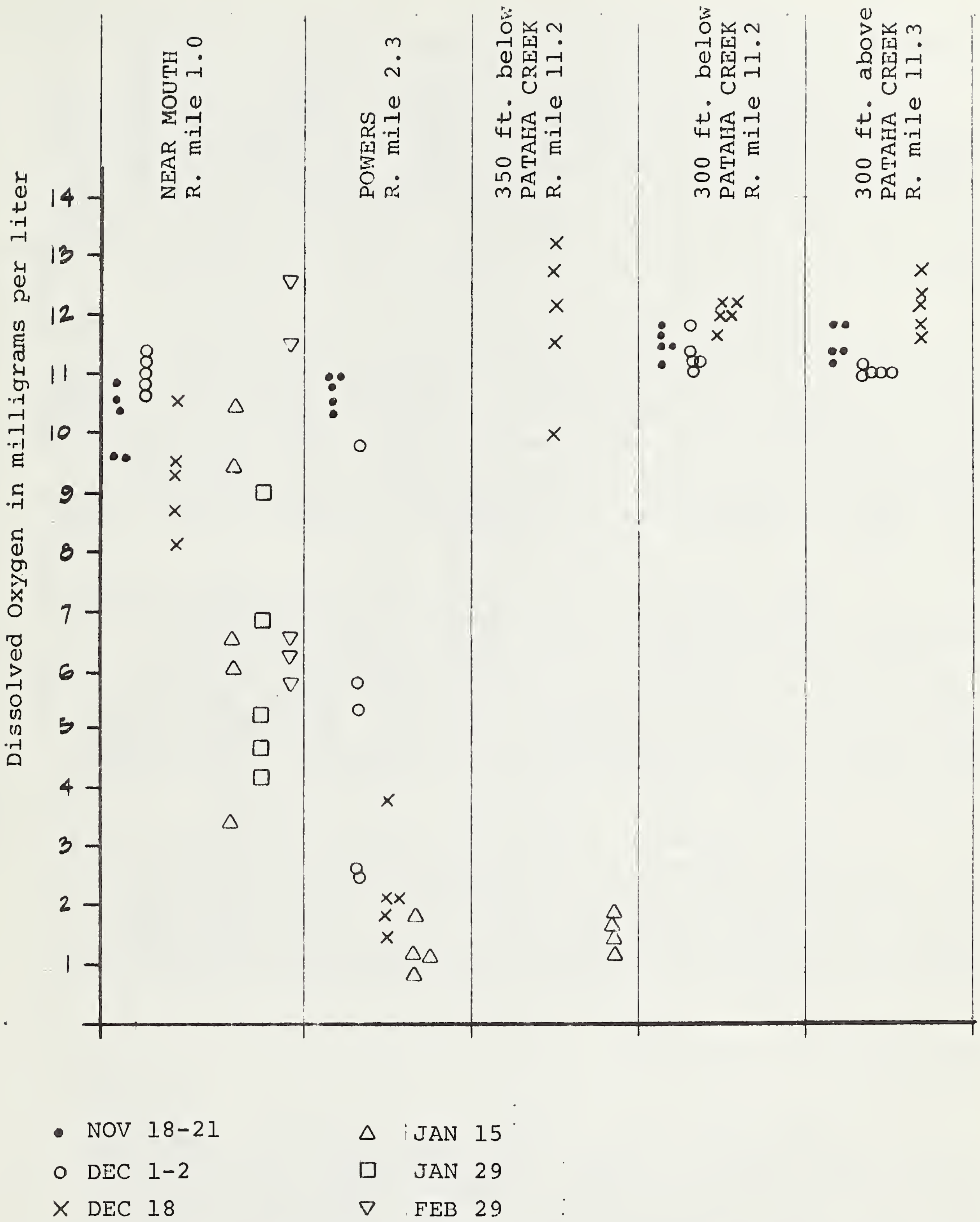


Figure 8. Fall and winter 1980 dissolved oxygen concentrations in simulated salmon nests constructed Nov 18-21, 1980 at 4 stations in the lower Tucannon River.

January 15, all piezometers were washed away in a storm.

Essentially the same conditions applied to the first station built below Pataha Creek. It was constructed 350 feet below the mouth of Pataha Creek, also on the Blaine Fletcher's Ranch. Dissolved oxygen concentrations there remained at near saturation levels through the last measurement on December 18 and then the station was washed away. During this month there was very little flow in Pataha Creek and, therefore, very little opportunity for Pataha Creek to affect this lower station.

Anticipating the possible loss of this station because of streambed erosion here, five additional redds were built 500 feet downstream, in a somewhat more protected spot. These redds were built and piezometers installed in them on December 18. By January 15 a storm had washed away both of the stations above and immediately below Pataha Creek. Dissolved oxygen concentrations in four of the five nests of the remaining station, 350 feet below Pataha Creek, had dropped below 2 mg/l. The fifth piezometer was so clogged with sediment that it was impossible to extract a water sample from it.

The five nests built just above Powers Road in mid-November 1980, suffered a rapid and continuing decline in dissolved oxygen concentrations from the time they were installed in mid-November. Salmonid eggs would not have hatched here. The substrate in this reach had a very hard seven inch crust of gravel and fine silt. Below that crust, the gravel was reasonably soft and loose although very muddy. Building the nests cleaned the gravel adequately, but within a month dissolved oxygen levels were 2 mg/l or less.

The last nests simulated in November 1980 were built just above the backwater of the lower Monumental Reservoir. The gravel here was loose and dissolved oxygen concentrations in them remained surprisingly high. Of all the sites below Pataha Creek, this is the only one where we would expect significant survival of salmonid eggs deposited in the gravel during the winter.

EFFECTS OF REDD BUILDING

During our study, a very large number of dissolved oxygen measurements were made with standpipes driven into the stream gravel adjacent to the simulated steelhead nests (fig. 9). Dissolved oxygen concentrations in such undisturbed gravel bear only a slight relationship to those in the nests where gravel has been excavated, the fines removed, and the depressions filled with coarse material. Had we used data gathered in

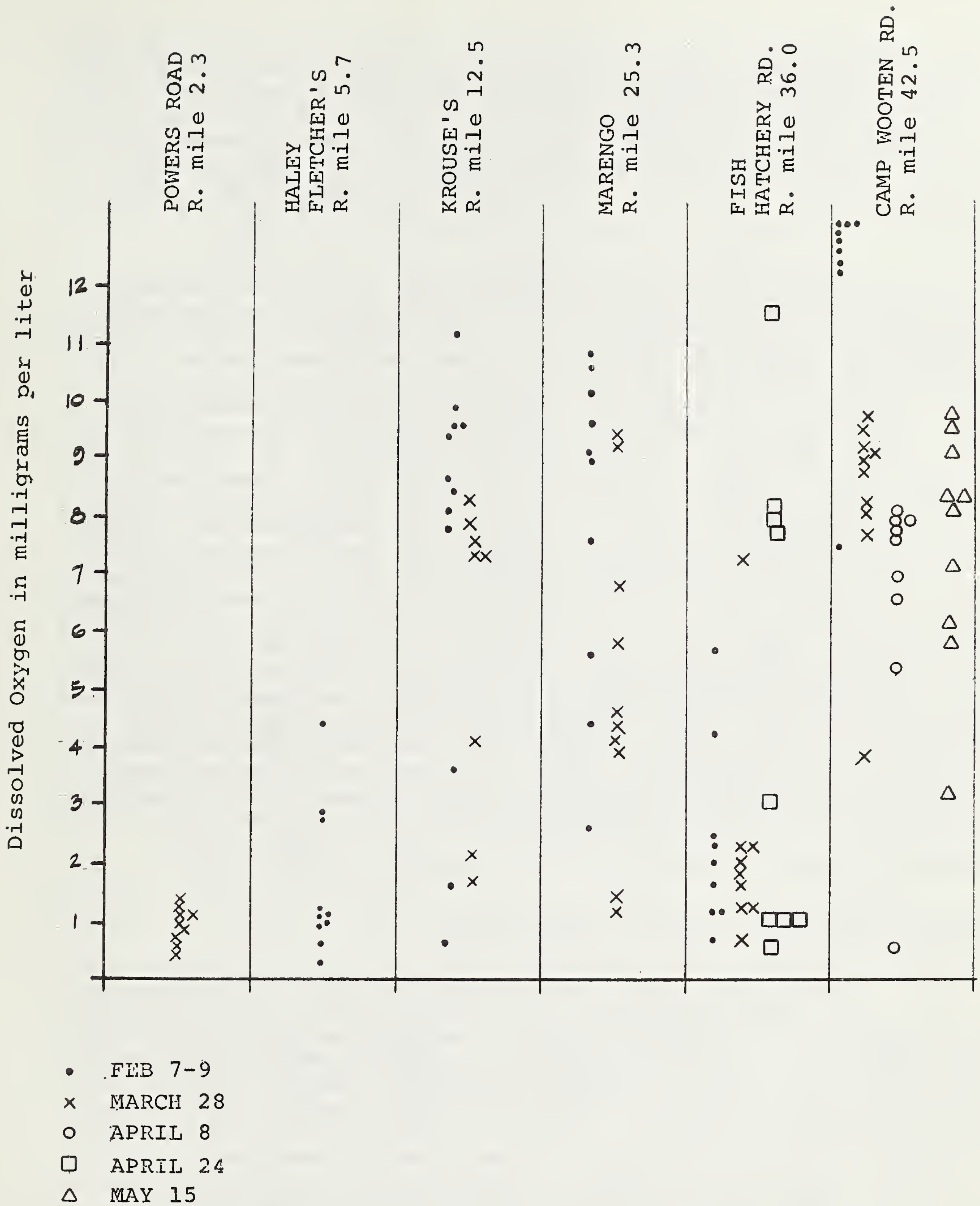


Figure 9. Concentrations of dissolved oxygen in standpipes driven into the substrate, Tucannon River, winter and spring, 1980.

driven standpipes, we would have concluded that successful egg incubation was likely only about half of the time at Camp Wooten, Marengo, and Krouse's, and would rarely have been successful at the Hatchery Station. Those conclusions would have obviously been erroneous, because they did not consider the very great importance of the fish cleaning the gravel during nest building. The matter has been investigated by many others. Some of that work is reviewed in Armstrong's Appendix.

Our review of that information and our own investigations lead us to conclude that dissolved oxygen concentrations subsequent to the construction of nests depend largely upon the continued exchange of stream water and intragravel water. The matter can be dramatically demonstrated by injecting dye on the surface of the bottom several feet upstream from a nest site prior to its construction and then doing the same after a nest has been built. To satisfy our curiosity, we did this in several places. In all cases, the dye released above undisturbed sites formed a plume from the tip of the syringe needle, rose slightly from the needle and rapidly dispersed in a dilute cloud downstream. The dye traveling over the disturbed gravel of a newly built redd, behaved very differently. No plume at all was formed. Instead, the dye rose slightly, then flattened out horizontally and, in spite of current velocities approaching 2 feet per second, dove into the nest. In some cases, the dye traveled upstream before entering the nest. It is our opinion that successful egg incubation will depend upon maintaining this exchange between surface and intragravel water in the nest. To the degree that it is prevented by the deposition of fine material, the intragravel water inside the nest becomes water exposed to increasing amounts of oxygen demand. Even though its rate of underground movement through the nest may be reasonably high, the high dissolved oxygen concentrations needed for egg incubation are not likely to be sustained.

CAUSES OF DISSOLVED OXYGEN DEFICIENCIES

To obtain additional information about what caused differences in intragravel dissolved oxygen concentrations, Ivan Lines, Jr. and Paul Rogers of the USSCS made a number of additional measurements between March 3 and May 14, 1981. They established five new sampling stations toward the lower end of the river where our previous investigations had suggested there were major differences in intragravel dissolved oxygen.

Their Willow Creek Station was above the influence of both Willow and Pataha Creeks - both tributaries that supply large amounts of suspended sediment to the Tucannon River during heavy runoff periods. Krouse Station received streamflow

from Willow Creek, but not from Pataha Creek. Pataha Creek Station was just downstream from Pataha Creek and received water from both of these contributing streams. Powers Station was just above the Powers Road Bridge, where substrate was heavily consolidated. Tucannon Mouth Station was just above the back waters of the reservoir, where the gravels were relatively unembedded by sediment.

In each of these stations, they measured the intragravel dissolved oxygen concentrations and temperatures with standpipes driven into the gravel and with minipiezometers in five simulated salmon nests. Besides measuring the dissolved oxygen and water temperatures, they retained the water samples taken from the gravel and made a series of measurements on that material which we believed might be related to the differences in dissolved oxygen concentrations. They found, as we did, that intragravel conditions changed dramatically when nests were built. The intragravel water samples collected from simulated nests, had lower conductivity, turbidity, concentrations of both suspended organic and inorganic solids, and usually lower temperatures (table 5). The intragravel water samples collected from the nests had slightly higher concentrations of nitrates and much greater dissolved oxygen concentrations than those taken prior to nest building.

The differences are the result of sediment being washed out of the gravel by stream currents as the nest is built. The increase in dissolved oxygen concentrations and the decrease in intragravel water temperatures reflect increased exchange of intragravel and stream waters long after nest construction. The increase in nitrate concentrations may mean that the subterranean water, with a higher source of nitrates, is entering the nest in significant quantities.

Most of the nests built by Lines and Rogers maintained adequate oxygen concentrations for steelhead eggs from March 3 through mid-April - a period sufficiently long to successfully hatch many eggs had they been present (fig. 10). By late April the DO concentrations in many had dropped low enough to either kill eggs or fry. Only those at the Willow Creek Station remained above 7 mm per liter. DO concentrations in all nests improved by the time equipment and personnel arrived to take freeze core samples six days to two weeks later. Rogers and Lines believe that the sudden fall in DO was the result of a storm in the Willow Creek drainage and an unseasonal hot spell.

The lower two stations of Tucannon Mouth and Powers had lethal temperature for salmonid eggs in the nests as early as March 12, 1981. All eggs will die in the nest when temperatures exceed 13.9° C. When the nests were monitored on April 30, 1981, there was an unseasonal warm spell. Paul Rogers measured air temperature at 33.1° C. and the coolest nests at Willow Creek at 13.5° C. The Tucannon Mouth nest temperatures were as high as 20.5° C. (table 6).

Table 5. Mean water quality of intragravel water before and after simulating salmon nests on the Tucannon River. Measurements made by Lines and Rogers, USSCS, March-May, 1981.

	March 3 Prenest	March 3	March 12	March 23	April 7-10	April 30	May 6-14
Electrical Conductivity (μmho)							
Near Mouth	189.8	27.6	41.6	45.4	35.8	81.4	66
Powers	111.6	59.4	44.2	54.6	62.2	68.8	84.4
Below Pataha Cr.	93.2	35.6	58.5	60	93.8	153	167.2
Krouse	35	32	37.4	47.6	38.4	97.6	88.4
Above Willow Ck.	91.8	23.8	42.2	49.4	48	42.4	50
Turbidity (NTU)							
Near Mouth	3106	20.8	33	22.6	19.8	2050	293.8
Powers	2920	8.6	198.2	819	85.8	153.2	108
Below Pataha Cr.	3460	27.2	1417.5	1674	3320	3900	4560
Krouse	4460	20.8	236.4	1076	1842	2211	2176
Above Willow Cr.	3460	30.4	180.8	108.2	562.2	29	19
Nitrate (mg/l)							
Near Mouth	1.87	4.17	2.57	5.07	2.04	5.00	1.74
Powers	1.87	2.99	2.40	2.02	3.65	1.98	2.00
Below Pataha Cr.	1.54	2.47	2.28	2.38	2.88	1.76	1.45
Krouse	1.98	2.47	2.60	2.09	2.02	1.90	1.73
Above Willow Cr.	1.28	1.63	1.79	1.92	1.67	2.03	2.54
Suspended Solids (g/l)							
Near Mouth	216.36	.54	7.88	.3	.26	35.16	3.1
Powers	205.86	.26	4.28	9.2	1.88	4	2.98
Below Pataha Cr.	267.54	.38	18.5	52.16	67.3	92.08	82.24
Krouse	76.22	1.48	2.7	5.88	9.48	35.36	30.34
Above Willow Cr.	74.66	1.16	1.50	.64	1.88	.6	.22
Suspended Organic Matter (g/l)							
Near Mouth	6.06	.009	1.11	.009	.02	1.56	.17
Powers	3.31	.20	.15	.92	.19	.19	.18
Below Pataha Cr.	3.09	.03	.54	1.28	2.41	3.91	2.51
Krouse	.74	.02	.13	.44	.57	2.75	1.30
Above Willow Cr.	3.23	.03	.07	.05	.20	.04	.02

Table 5. (continued)

	March 3 Prenest	March 3	March 12	March 23	April 7-10	April 30	May 6-14
Suspended Inorganic Matter (g/l)							
Near Mouth	210.3	1.05	6.77	.29	.24	33.6	2.93
Powers	202.55	.06	4.13	8.28	1.69	3.81	2.80
Below Pataha Cr.	264.45	.35	17.96	254.4	64.89	88.17	79.73
Krouse	75.48	1.43	2.57	5.44	8.91	32.61	29.04
Above Willow Cr.	71.43	1.13	1.43	.59	1.68	.56	.20
Nest Temperature (°C.)							
Near Mouth	8	8.2	12	14	10.8	19.9	13.1
Powers	9.9	9.8	14.46	13.6	8.5	18.9	12.4
Below Pataha Cr.	6.5	5.8	12.25	11.3	10.6	17.2	11.4
Krouse	8	7.1	9.1	9.3	9.3	15.2	8
Above Willow Cr.	10.5	9.5	6.5	10.2	9.2	13.5	9
% Ambient [DO](%)							
Near Mouth	59.2	101	97.2	83.6	81	62.4	86.4
Powers	38.2	98.2	94.6	77.2	68.6	54.2	68.4
Below Pataha Cr.	78.2	98.2	91.25	89.6	88.6	50.8	71.6
Krouse	73	98	97	92.4	70.6	51.2	55.6
Above Willow Cr.	89.6	98	92.8	85.4	84.6	72.4	68

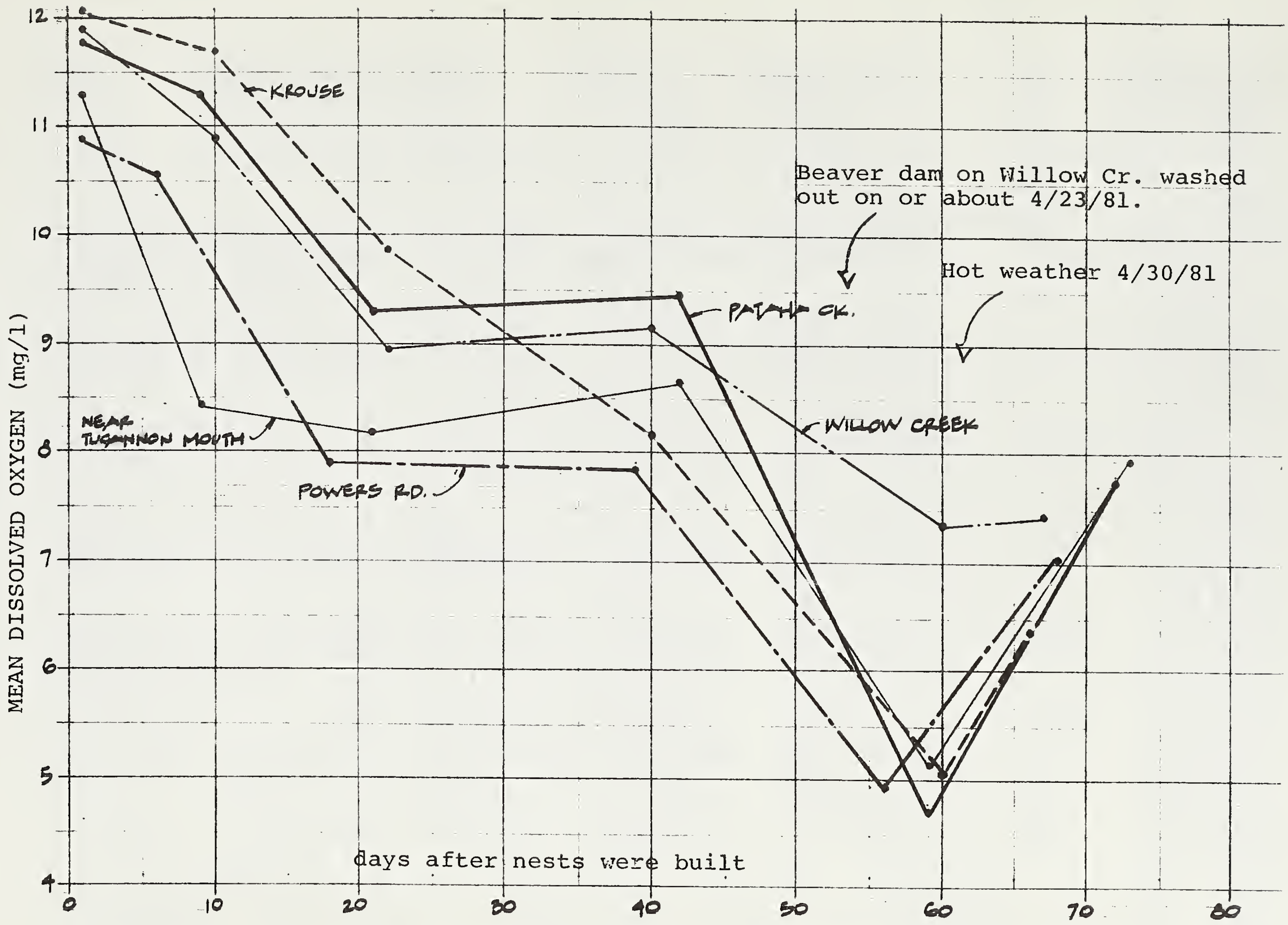


Figure 10. Mean dissolved oxygen concentrations in simulated salmon nests built at five stations on the Lower Tucannon River in early March, 1981.

Table 6. Intragravel temperatures (°C.) from 25 piezomaters buried in the lower Tucannon River March 1981. Lethal temperature for salmonid eggs is 13.89°C.

	DATE	3/3/81	3/3/81	3/12/81	3/23/81	4/7-10/81	4/30/81	5/6-14/81	
LOCATION		B	1	2	3	4	5	6	
Tucannon									
Piezometer	1	8	8	12.5	13.5	10.5	19.5	13	
"	2	8	8	12.5	14.5	11.0	20.5	13	
"	3	8	8.5	11.5	14.5	11	20.5	13	
"	4	8	8	12	14	11	20.0	13	
"	5	8	8.5	11.5	13.5	10.5	19.0	13.5	
		(8)	(8.2)	(12)	(14)	(10.8)	(19.9)	(13.1)	MEAN
Powers									
Piezometer	1	10	10	14.1	13	9	19	11	
"	2	10	10	14.1	13	8	19	12.5	
"	3	9.5	9.5	14.5	14	8.5	19	12.5	
"	4	10	10	14.6	14.5	8.5	19	13	
"	5	10	9.5	15	13.5	8.5	18.5	13	
		(9.9)	(9.8)	(14.46)	(13.6)	(8.5)	(18.9)	(12.4)	MEAN
Pataha									
Piezometer	1	6	6	12	11.5	11	18	10.5	
"	2	7	5.5	12	11	10.5	16.5	11.5	
"	3	6	5.5	12	11	10.0	18	11.5	
"	4	6.5	6	13	11.5	10.5	16.5	12.0	
"	5	7	6	clog.	11.5	11.0	17	11.5	
		(6.5)	(5.8)	(12.25)	(11.3)	(10.6)	(17.2)	(11.4)	MEAN
Krouse									
Piezometer	1	8	7.5	9.5	9.5	9.5	14.5	8	
"	2	7.5	5.5	9	9	9.5	14.5	8	
"	3	8.5	7.5	9	9	9.5	14.5	8	
"	4	8	7.5	9	9.5	9.5	17.5	8	
"	5	8	7.5	9	9.5	9.5	15	8	
		(8)	(7.1)	(9.1)	(9.3)	(9.5)	(15.2)	(8)	MEAN
Willow Cr.									
Piezometer	1	11.5	9.5	6.5	10.5	9.5	13.5	9	
"	2	12	9.5	6.5	10.5	9.5	13.5	9	
"	3	10	9.5	6.5	10.5	9.0	13.5	9	
"	4	9.5	9.5	6.5	9.5	9	13.5	9	
"	5	9.5	9.5	6.5	10	9	13.5	9	
		(10.5)	(9.5)	(6.5)	(10.2)	(9.2)	(13.5)	(9)	MEAN

Using least squares linear regression, Li assessed the relationships between ambient dissolved oxygen concentrations at each station, and other variables that Lines and Rogers had measured including organic and inorganic sediment. All but the nitrate concentrations were inversely correlated with DO (fig. 11). Electrical conductivity, nest temperatures, and suspended organic solids, together explain 44% of the differences in percent ambient DO (table 7).

FREEZE CORE SAMPLES FROM SIMULATED NESTS AND UNDISTURBED STREAM BOTTOM

By April 30, 1981, about half of the redds built by Lines and Rogers in early March had low DO concentrations. At this time Rogers, and Dr. Ted Bjornn of the University of Idaho, collected freeze core samples of the bottom from each simulated nest site. They divided each frozen core into three subsections; the top 7 inches, a middle 7 inches, and a bottom 6 inches. These dimensions were chosen because in the first samples, bands of silt occurred at 7 and 14 inches below the gravel surface.

These core samples were difficult to take in the Tucannon River. The fast stream velocities prevented the surface of 23 of the 32 samples from completely freezing, despite a protective shroud that quieted the flows around the sampling apparatus. Varying amounts of samples were therefore lost from the top sections as the samples were pulled from the river and often fine particles were washed away.

Rogers noted that all of the samples had a surface zone that was free of silt and interstitial fines and the zone of clean gravel that varied from 1½ to 7 inches deep. Below this clean zone the silt appeared to have gradually accumulated with depth, usually concentrating around 7 inches below the surface to form a noticeable layer of silt. We believe this is the result of fast current velocities in the river keeping the initial layers of gravel clean of fine sediment. A layer of silt accumulates in the gravel as the suspended sediment falls into crevices away from the influence of current. That layer may greatly reduce the interchange of stream and intragravel water and have a major effect on the dissolved oxygen concentrations in the bottom of salmon and steelhead nests in this lower end of the river.

Rogers noted that the middle sections (7 to 14 inches) in simulated nests usually contain concentrations of silt that increased with depth and ended with a mixture of silt and small amounts of sand and gravel. This second band of silt at about

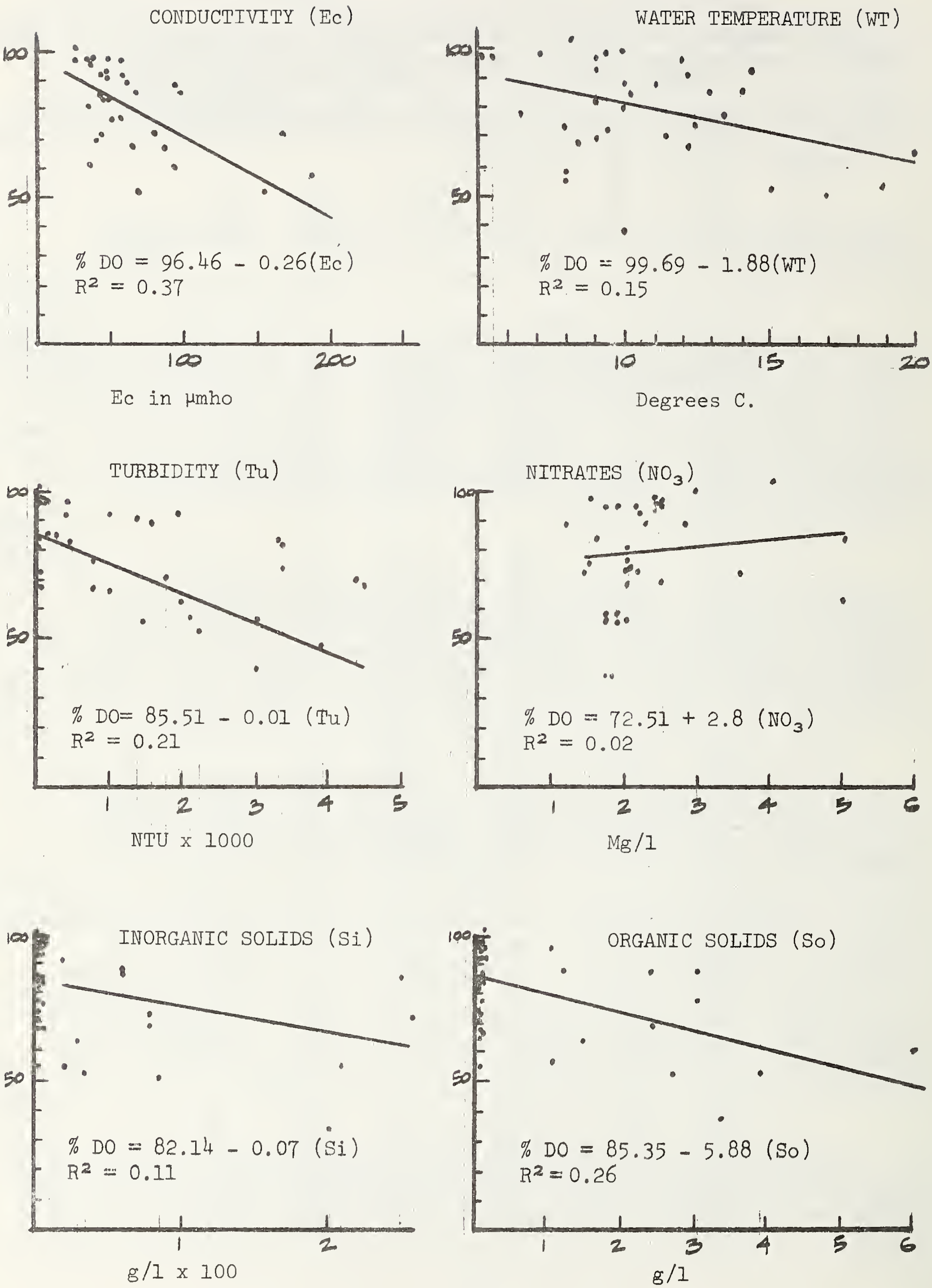


Figure 11. Least squares linear regression correlation between intragravel DO ÷ ambient stream DO x 100 (%DO), and other characteristics of intragravel water in simulated salmon nests measured with minipiezometers at five stations in the Tucannon River from early March to mid-April.

Table 7. Multiple linear regression of suspended organic solids, nest temperature, and electrical conductivity with percent ambient dissolved oxygen concentrations from simulated nests in the lower Tucannon River, March-May, 1981. Percent ambient (DO) = a + b suspended organic solids + c nest temperature + d electrical conductivity.

STATION	R^2	(intercept w/ DO axis) a	Slope b Suspended Organic Solids	Slope c Nest Temperature	Slope d EC
All Stations	.44	109.31	- .40	-1.36	-.22
Near Mouth	.84	122.52	1.40	-1.79	-.30
Powers	.78	149.49	-2.78	-1.93	-.75
Below Pataha Cr.	.89	114.61	-5.52	-1.23	-.10
Krouse	.87	51.28	-33.05	4.98	.12
Above Willow Cr.	.72	140.53	15.39	-2.40	-.82

14 inches was not pressed in the freeze core samples taken from undisturbed substrate outside of the simulated nests. We hypothesized that the loose gravel of the nests must allow further downward migrations of suspended sediments until they accumulate at the bottom of the nest. Rogers believes that the small amounts of sand and gravel are stream particles that were disturbed but not completely cleaned out of the nests when the piezometers were planted.

The bottom sections of the frozen cores usually contained moderate amounts of uniformly distributed sand, gravel, and silt. They were much like the bottom of freeze core samples taken from outside the nests.

For quantitative analysis Li omitted those samples that Rogers said had lost a great deal of material during the freeze coring (table 8).

Li used multiple linear regression to correlate deposited organic matter, percent fines, and concentrations of suspended organic matter with percent ambient dissolved oxygen concentration from each redd on the day the freezecore samples were taken.

The estimates used in this regression were the following:

Deposited organic matter was the percentage of organic matter in the sample passing the .074 mm sieve.

Percent fines was the percentages from 0.595 mm size class.

Suspended organic solids was the concentration of organic solids sucked from the piezometers.

Percent ambient dissolved oxygen concentration was the quotient of the redd DO divided by the stream DO.

All percentages were Arcsin transformed.

These three factors accounted for 55% of the variance related to the depression of dissolved oxygen concentrations in nests in the lower Tucannon River in May 1981. They were all inversely correlated with percent ambient dissolved oxygen concentration. Percent fines was most influential, followed by suspended organic solids, then percent deposited organic matter (table 9).

Table 8. Size class analysis of freeze core samples from the Tucannon River, April 1981. Figures are mean percent material smaller than the named size classes.

STATION	REDD				UNDISTURBED GRAVEL			
	0.595 mm	1.190 mm	6.35 mm	n	0.595 mm	1.190 mm	6.35 mm	n
Near Mouth								
Top 7"	3.83	5.76	20.51	3	8.71	10.48	22.64	2
Middle 7"	10.11	13.75	35.34	3	12.81	16.78	38.36	2
Total sample	8.04	10.78	30.43	3	11.4	14.58	32.85	2
Powers								
Top 7"	4.76	6.06	9.38	4	5.96	8.74	16.45	2
Middle 7"	10.27	13.61	22.86	5	8.23	11.75	26.06	2
Total sample	8.85	11.45	19.02	4	6.95	10.33	21.61	2
Below Pataha Cr.								
Top 7"	4.05	4.52	6.74	3	5.91	7.44	17.38	2
Middle 7"	10.37	11.88	19.66	5	7.60	8.95	15.83	2
Total sample	7.49	8.52	13.84	3	7.36	8.89	17.20	2
Krouse								
Top 7"	6.12	6.68	9.22	5	8.59	11.13	22.13	2
Middle 7"	9.29	12.07	19.34	4	8.72	11.65	21.96	2
Total sample	8.51	10.47	16.84	4	8.71	11.51	22.00	2
Above Willow Cr.								
Top 7"	8.32	10	18.96	1	1.23	2.06	11.58	2
Middle 7"	7.12	9.96	22.74	4	4.43	6.51	18.73	2
Total sample	7.35	9.70	22.21	1	3.50	5.21	16.43	2

Table 9. The multiple linear regression of deposited organic matter, percent fines less than .595 mm, and suspended organic solid concentrations with percent ambient dissolved oxygen concentration from individual nests in the lower Tucannon River, May 1981.

	Weight sieved sample (g)	Organics (g) deposited	Percent organics deposited	Arcsin % organics deposited	Percent fines <.595 mm.	Arcsin % fines <.595 mm.	Suspended organic solids (g/1)	Percent ambient [DO]	Arcsin % ambient [DO]
NEAR MOUTH									
Piezometer #2	397.7	5.8	1.46	6.94	4.85	12.73	.28	107	105.34
" 4	471.7	10.61	2.25	8.63	8.26	16.70	.08	87	68.87
" 5	489.8	15.68	3.20	10.31	11.02	19.39	.37	34	35.67
POWERS									
Piezometer #1	506.2	10.4	2.05	8.23	8.26	16.70	.25	61	51.25
" 3	480	15.9	3.31	10.49	9.10	17.56	.14	77	61.34
" 4	530.3	17.11	3.23	10.37	9.35	17.80	.14	82	64.9
" 5	501.5	14.09	2.81	9.65	8.69	17.15	.07	61	51.34
BELOW PATAHA CR.									
Piezometer #2	399.9	8.5	2.13	8.39	10.73	19.11	3.06	69	56.17
KROUSE									
Piezometer #1	410.6	10.58	2.58	9.26	11.37	19.70	.1	43	40.98
" 4	417	9.99	2.40	8.91	8.81	17.26	1	56	48.45
" 5	473.7	8.89	1.88	7.87	6.53	14.80	3.88	56	48.45
ABOVE WILLOW CR.									
Piezometer #1	517.2	9.48	1.83	7.77	7.35	15.73	.03	64	53.13

$R^2 \doteq .55$

Percent Ambient [Dissolved oxygen] = 171.42 - 0.41 percent deposited organic matter - 6.34 percent fines - 3.14 suspended organic matter.

CHAPTER IV. PERIPHYTON

"Periphyton" is the term describing the community of algae, fungi, bacteria, protozoa, etc., that grow together on fixed solid substrate under water. US Soil Conservation Service staff specifically requested that periphyton be measured as an index of stream health.

Methods

Dr. Li collected periphyton early in July 1980, and again in early September 1980, at the five stations along the Tucannon where our first studies of substrate conditions for salmonid egg hatching were conducted. He collected periphyton from 3 or 4 rocks in moderate current that were fully exposed to the sun. He scribed a 1.5" circle on each rock using a pipe as a pattern and removed the periphyton from the circled surface using a coarse bristle artists brush. The periphyton from one-half of each circle was placed in a labeled 7 dram snap cap vial filled with stream water, and immediately placed into a light tight ice chest. The samples were analyzed for chlorophyll content, ash-free weight, and dry weight in Dr. Michael Falter's laboratory at the University of Idaho. The time between collection and analysis was always less than 24 hours.

One half of each sample was used for chlorophyll analysis, and the other was for ash-free weight analysis. Chlorophyll concentrations were measured with a Bausch and Lomb Spectronic 70 Spectrophotometer.

To extract the chlorophyll from the sample, Dr. Li macerated the filamentous and leafy samples using a tissue homogenizer (Virtis 45) and filtered the samples under vacuum pressure (under 10 psi) using 0.45 μm pore size Millipore filters. Both filters and samples were placed in a centrifuge tube, where 10 ml of 90% acetone dissolved the filter and began extracting the chlorophyll. The samples were placed overnight in a refrigerator to complete the extraction process.

The next morning, each sample was centrifuged to minimize the turbidity (a source of error in the analysis), then placed into a cuvette (1 cm light-path). Dr. Li tried to minimize exposing the samples to light because chlorophyll is subject to bleaching. To estimate chlorophyll content, he measured the optical densities of each sample using both the trichromatic method of Richards and Thompson (1952) and the phaeophytin corrected method of Lorenzen (1967). In each case, the samples were compared with an identical cuvette

filled only with 90% acetone.

To determine dry weight, ash weight, and ash-free weight, Dr. Li weighted the samples using an analytical beam balance (Mettler H10w) before and after drying and ashing procedures.

Dry weight is the weight of the sample after all the water has been removed with an oven (105° C. for at least 20 hours). Ash weight is the weight of the sample after the organic matter was vaporized in a muffle furnace (500° C. for one hour). The ash-free weight was corrected for carbonate loss and is an estimate of organic content (EPA, 1973).

Dr. Li collected three samples of periphyton at each of these stations in July and four samples per station in September. At both times periphyton was abundant everywhere (table 10). Concentrations exceeded those that other investigators have found in the Logan River, Utah and in a soft water stream, Bere Stream, in England, and were similar to those grown under controlled conditions in Oregon (table 10).

Table 10. The concentration of periphyton in the Tucannon River compared with other aquatic environments.

LOCATION	DRY WEIGHT (g/m^2)	Chlorophyll A (mg/m^2)	SOURCE
Tucannon River, WA	63-128	13-36.43	(this study)
Logan River, UT	25	300	McConnell & Sigler, 1958
Bere Stream, England	12-15	50-75	Marker, 1976
Laboratory stream, OR	55-110	195-380	McIntire, 1966*

* Estimated from figures in text.

Mean biomass of periphyton doubled between July and September (fig. 12). The July mean was 63 g/m^2, while September's collection averaged over 128 g/m^2. Three stations contributed to this doubling--Hatchery, Marengo, and Fletcher. Periphyton at Wooten increased only slightly and at Krouse's periphyton decreased between sampling periods.

Mean chlorophyll _a_ concentrations in the Tucannon River periphyton samples doubled from July to September.

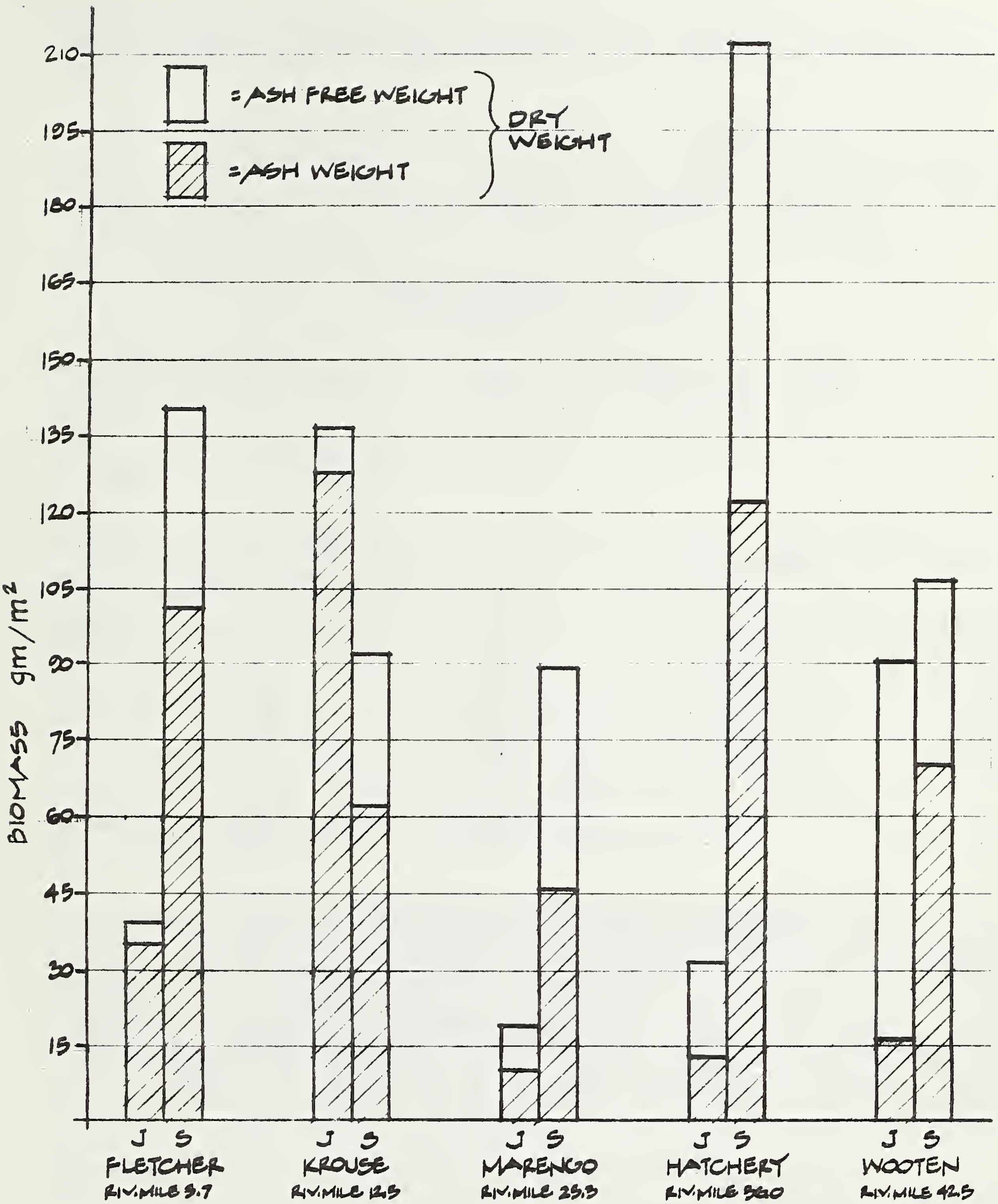


Figure 12. Mean concentration of periphyton at five stations in the Tucannon River in July and September, 1980.

Concentrations seemed low. They were exceeded by samples from the Logan River, Utah, Bere Stream, England, and laboratory streams in Oregon (table 10).

The chlorophyll content of periphyton expressed as the ratio between total organic weight and chlorophyll a has been suggested as an index of stream "health" or "physiological condition" (Weber, 1973). We calculated "autotrophic indexes" (AI) on the samples collected from the Tucannon River where:

$$AI = \frac{\text{ash=free weight (mg/m}^2\text{)}}{\text{chlorophyll (mg/m}^2\text{)}}$$

The mean autotrophic index increased from 1288 in July to 1614 in September (table 11).

Table 11. Autotrophic indexes for Tucannon River, 1980.

STATION	RIVER MILE	JULY	SEPTEMBER
Wooten	42.5	846	2846
Hatchery	36.0	3644	1219
Marengo	25.3	901	713
Krouse	12.5	961	1956
Fletcher	23	90	1337
		1288	1614

Autotrophic indexes were originally used by oceanographers to assess the condition of marine plankton by measuring the organic matter and chlorophyll in marine seston. The Environmental Protection Agency (EPA) adapted the AI for use in the federal water pollution control program as a measure of changes in plankton and periphyton species composition that may be related to water quality. The idea was that polluted water would encourage more heterotrophic organisms and thus have higher AI values/1 (Weber, 1973).

We find the autotrophic indexes for the Tucannon River difficult to interpret. They may indicate that the river is relatively heterotrophic. Many low order streams are, of course,

/1 Higher AI actually indicates less autotrophy and more heterotrophy.

heterotrophic and depend upon allochthonous material for energy to drive their biological production (e.g., Cummins, 1973; Minshall, 1967; Nelson and Scott, 1962).

On the other hand, a high AI may also be indicating the seasonal senescence of the periphton community. Contributing to our high AIs were the high percentages of phaeopigment in each sample (fig. 13). It made up 63-86% of the total pigment in July and 30-70% of the pigment in September. Phaeopigment (Phaeophytin) is nonphotosynthetic or degraded chlorophyll. Large concentrations such as we found suggest that the periphyton community may be senescent. Dr. Stanley V. Gregory of Oregon State University, has found sensescent periphyton communities in midsummer to late autumn in Oregon Cascade streams. Since the source of the phaeopigment can be either dead periphyton or allochthonous material like leaf litter, senescence cannot be assumed. We suspect, however, that it is the cause of high AI in the Tucannon River and that it is not an unnatural phenomenon.

We suggest that the autotrophic index has little value for comparing different bodies of water. The assumption that <u>all</u> or even most plankton and periphyton communities are dominated by algae is questionable. Its use as an index of pollution assumes erroneously that nonphotosynthetic organisms such as bacteria, yeast and molds, and protozoa--which are part of the periphyton community, reduce water quality. While organic pollution can increase populations of these organisms, their abundance does not necessarily indicate pollution. These organisms serve essential roles in colonizing allochthonous detritus and in breaking it down. The aquatic invertebrates that function as shredders of allochthonous material are nutritionally dependent upon them in the same manner that cows need microflora (Cummins, 1974).

Percent organic matter is probably a more useful measure in our case. Periphyton collected from the Krouse and Fletcher Stations in July contained much lower percentages of organic matter than periphyton collected at upstream stations (table 12). We believe this was probably because of their exposure to Willow Creek and Pataha Creek that periodically discharge large amounts of fine sediment into the Tucannon River. Such sediment is entrapped in periphyton and would reduce its organic content. It may also reduce its health or palatibility to insects and other invertebrates. The differences that were obvious in July had disappeared by September.

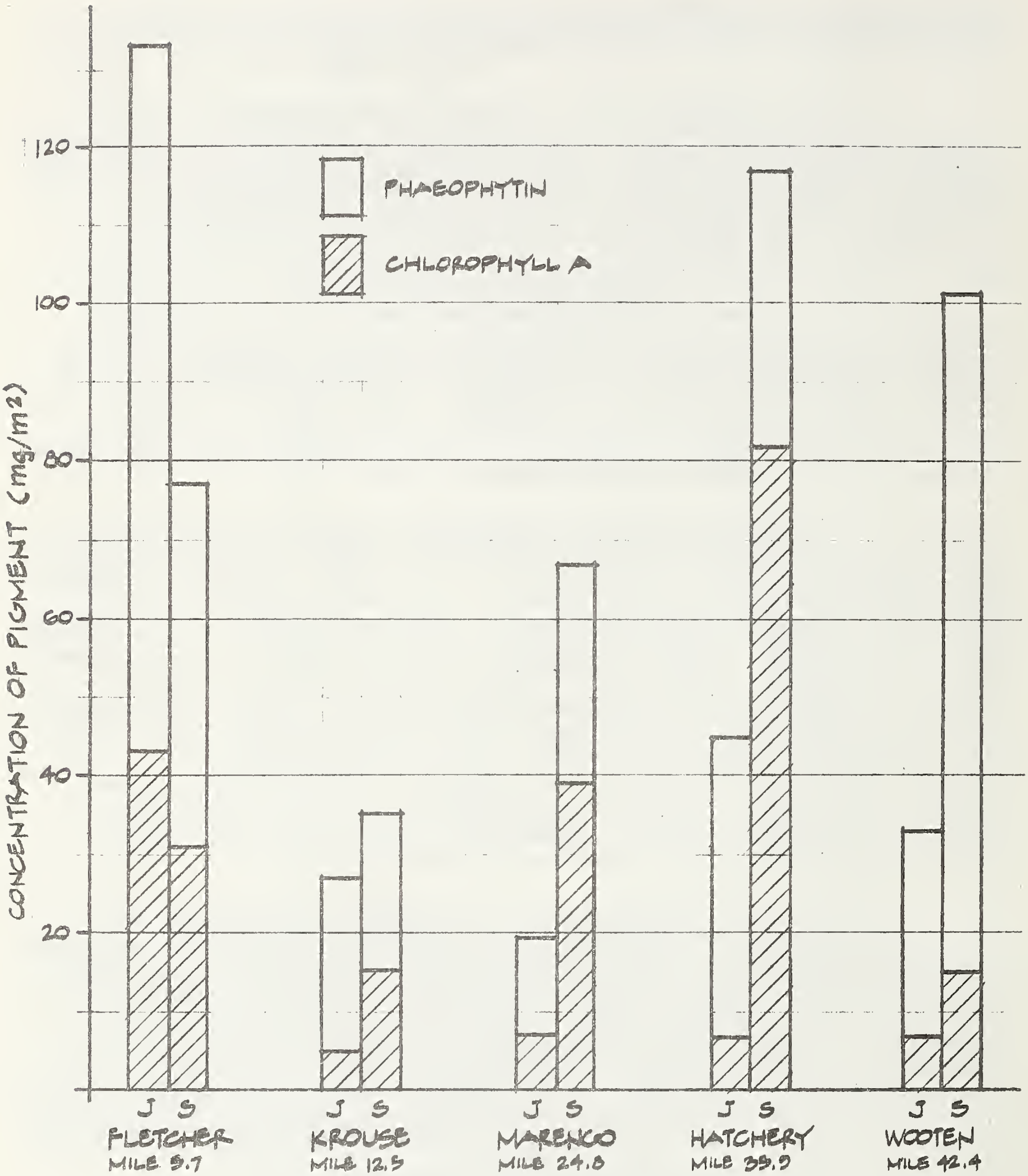


Figure 13. Concentration of pigment in July and September periphyton samples.

Table 12. Percentage of organic matter* in July and September periphyton samples.

STATION	JULY		SEPTEMBER	
	mean percent organic (%)	mean density (g/m^2)	mean percent organic (%)	mean density (g/m^2)
Wooten	66.24	74.50	39.06	38.65
Hatchery	59.53	18.42	46.58	90.09
Marengo	46.76	8.86	49.97	44.07
Krouse	7.25	7.55	31.84	30.58
Fletcher	11.79	3.51	21.47	39.12

* Ash-free weight/dry weight

CHAPTER V. AQUATIC INVERTEBRATES

We collected benthic samples during late June and early to mid-July, and again in early September, at the five stations along the Tucannon where measures had been made of how substrate conditions were affecting salmonid egg hatching and where periphyton samples were collected. The only usable information came from collections made with a Surber sampler with a mesh size of 0.8 mm. Our efforts to provide better information with basket samplers similar to those Coleman and Hynes (1970) buried and retrieved following colonization, failed. Some of these samplers were washed away or buried in sediment and gravel during storms. And as we continued to work with those samplers not lost, it became obvious that conditions within them were very different than in the surrounding substrate. We ultimately decided to not use the little information collected with them.

The June Surber samples collected at Wooten and the Hatchery sites with the Surber sampler, were hand sorted by Dr. Li on the stream bank, but all others were sorted later in our laboratory by students working under the direction of W. C. Fields, Jr., of Hydrozoology. Mr. Fields made all of the identifications and counts (table 14) and retains the collection for future reference.

Dr. Li collected 12 Surber samples at each of the five stations in June or July and three per station in September. Counts of the June/July collections were evidence that about 70% of the total number of species found in 12 Surber samples were found in the first three (table 13).

Table 13. Numbers of species collected in 12 and in 3 Surber samples during June and July, 1980, Tucannon River.

STATION	MILES FROM MOUTH	SPECIES IN 12 SAMPLES	SPECIES IN 3 SAMPLES	PERCENTAGE CAUGHT IN 3 SAMPLES
Wooten	42.5	59	40	67.80
Hatchery	36.0	48	32	66.67
Marengo	25.3	61	44	73.13
Krouse	12.5	47	36	76.60
Fletcher	2.3	49	34	69.30
		COLLECTION MEAN		70.70

Table 14. Tucannon River benthos, June, July, and September, 1980. Numbers are total organisms collected. Feeding habits are listed as: shredders (Sh); scrapers (S); collector-gatherers (C-G); filter feeders (F); predators (P); microfilter feeder (MF); micropredator (MP); collector-microgatherer (C-G); nonfeeder (NF); or unknown (U).

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
JUNE-JULY, 1980
PAGE 1 of 3

INSECTS

ORDER	FAMILY	GENUS & SPECIES	TROPHIC HABITS	12° COMBINED SURBER SAMPLES — SAMPLING SITE: WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
EPHEMEROPTERA	HEPTAGENIIDAE	*Cinygmula* sp.	S, C-G	53	4	1		
		Epeorus albertae	S, C-G		15	32		
		E. longimanus	S, C-G	9				
		Heptagenia criddlei	S, C-G			33	2	
		H. simplicioides	S, C-G				6	9
		Rhithrogena morrisoni	S, C-G		2	6	1	21
	BAETIDAE	*Baetis bicaudatus*	C-G	3	11	25	4	232
		B. tricaudatus	C-G	18	14	10	15	589
	LEPTOPHLEBIIDAE	*Paraleptophlebia* sp. A	C-G	27	7	11		
	EPHEMERELLIDAE	*Ephemerella doddsi*	P, C-G	2				
		E. flavilinea	C-G	21	8	4		
		E. grandis ingens	C-G	3				
		E. heterocaudata	C-G	26				
		E. infrequens	C-G	23				
		E. tibialis	C-G	1	1	32		
		Ephemerella (Subgenus *Attenella*) sp. A	C-G			60		
	TRICORYTHIDAE	*Tricorythodes minutus*	C-G				1	16
PLECOPTERA	PTERONARCYIDAE	*Pteronarcys californica*	Sh, S	6	11	25	1	4
		Pteronarcella badia	Sh, S	1		17		6
	PERLODIDAE	*Kogotus* sp.	P, S	7				
		Skwala sp.	P		1	30	3	55
	PERLIDAE	*Calineuria californica*	P	2	2			
		Claassenia sabulosa	P	10	1	11	11	10
		Hesperoperla pacifica	P	18	1	1		
TRICHOPTERA	RHYACOPHILIDAE	*Rhyacophila insularis* (P)	NF			1		
		Rhyacophila sp. A (acropedes Group) (L)	P	1				
	GLOSSOSOMATIDAE	*Glossosoma traviatum* (L/P)	S/NF	5/3	8/26	37/77	4/Ø	1/Ø
		G. pterna (L/P)	S/NF		6/11			
		Protoptila coloma (L/P)	S/NF			2/3	2/3	6/2
	PHILOPOTAMIDAE	*Wormaldia gabriella* (L/P)	F/NF			65/2	1/Ø	2/Ø
	HYDROPSYCHIDAE	*Cheumatopsyche* sp. (L/P)	F/NF				14/Ø	1/Ø
		Hydropsyche occidentalis (L/P)	F/NF		3/Ø	321/25	42/1	
		Hydropsyche sp. A (L/P)	F/NF				1/Ø	68/3
		Symphitopsyche sp. A (L/P)	F/NF	59/5	19/8			
		Symphitopsyche sp. B (L/P)	F/NF					9/6
	HYDROPTILIDAE	*Hydroptila* sp. (L)	S					1
		Leucotrichia pictipes (L)	S					1
	BRACHYCENTRIDAE	*Brachycentrus americanus* (L/P)	F, S/NF	134/5	138/10	428/1	1/Ø	7/Ø
		Micrasema sp. (L)	Sh	1				

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
JUNE-JULY, 1980

	Initials	Date
Prepared By		
Approved By		

INSECTS

ORDER	FAMILY	GENUS & SPECIES	TROPHIC HABITS	12° COMBINED SURBER SAMPLES — SAMPLING SITE: WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
TRICHOPTERA	LEPIDOSTOMATIDAE	*Lepidostoma* sp. A (L/P)	Sh	31/11	5/23			
		Lepidostoma sp. B (L)	Sh	2				
	LIMNEPHILIDAE	*Dicosmoecus gilvipes* (L)	S	17	10	11		
		Neophylax rickeri (L/P)	S/NF	9/3	Ø/1			
		Onocosmoecus sp. (L)	Sh	2				
	LEPTOCERIDAE	*Oecetis avara* (L)	P			16	3	1
	HELICOPSYCHIDAE	*Helicopsyche borealis* (L/P)	S/NF			51/Ø	2/1	
LEPIDOPTERA	PYRALIDAE	*Parargyractis* sp. (L)	F					1
COLEOPTERA	ELMIDAE	*Cleptelmis* sp. (L)	S, C-G	2				
		Optioservus quadrimaculatus (L/A)	S, C-G	13/74	14/74	36/10	7/4	13/44
		Ordobrevia nubifera (A)	S, C-G	1		2		
		Zaitzevia parvula (L/A)	S, C-G	Ø/1		Ø/2	Ø/2	2/3
		Narpus concolor (L/A)	Sh	8/1	5/Ø	2/Ø	1/Ø	
DIPTERA	TIPULIDAE	*Antocha* sp. (L/P)	C-G/NF	20/2	8/2	5/Ø	1/Ø	
		Hexatoma sp. (L)	P	1/Ø	Ø/1			
	TANYDERIDAE	*Protanyderus* sp. (L)	U			1	1	
	SIMULIIDAE	*Simulium griseum* (L/P)	MF/NF			2/Ø	3/Ø	5/2
	CHIRONOMIDAE	*Pentaneura* sp. (L)	MP			1		
		Thienemannimyia GROUP (UID) (L/P)	MP/NF	1/Ø		3/1		1/2
		UID TANYPODINE PUPA A	NF			1		2
		Cladotanytarsus sp. (L/P)	MF/NF		9/Ø	1/Ø		1/1
		Micropsectra sp. (L/P)	C-MG/NF	3/Ø	2/Ø	3/1	1/Ø	1/1
		Rheotanytarsus sp. A (L/P)	MF/NF	Ø/1		9/Ø	3/1	4/7
		Cryptochironomus sp. (L)	MP		1			
		Demicryptochironomus sp. (L/P)	C-MG/NF					1/2
		Microtendipes sp. (L)	MF	5	1			
		Phaenopsectra sp. (L)	C-MG				1	
		Polypedilum sp. A (L/P)	MF/NF	11/Ø	1/Ø	97/11	5/1	267/9
		Polypedilum sp. B (L)	MF				6	
		UID CHIRONOMINE PUPA A	NF					1
		Brillia sp. (L)	Sh			1		
		Corynoneura sp. (L)	C-MG				1	
		Cricotopus sp. A (*tremulus* GROUP) (L)	C-MG	13	34	17		
		Cricotopus sp. B (*bicinctus* GROUP) (L)	C-MG				54	2
		Eukiefferiella sp. A (*bavarica* GROUP) (L/P)	C-MG/NF	2/Ø		3/1		2/Ø
		Eukiefferiella sp. B (*claripennis* GROUP) (L/P)	C-MG/NF		1/Ø	38/5	43/4	2/Ø
		Eukiefferiella sp. C (*discoloripes* GROUP) (L/P)	C-MG/NF	1/1	2/2	10/Ø	1/Ø	1/Ø
		Eukiefferiella sp. D (*potthastia* GROUP) (L)	C-MG			9	5	4
		Heterotrissocladius sp. (L/P)	C-MG/NF	Ø/1		Ø/1	1/Ø	

Made in U S A

4804 (84804) — Buff
8804 (88804) — Green

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
JUNE – JULY, 1980
Page 3 of 3

INSECTS

ORDER	FAMILY	GENUS & SPECIES		TROPHIC HABITS	WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
					12° COMBINED SURBER SAMPLES – SAMPLING SITE				
DIPTERA	CHIRONOMIDAE	*Nanocladius branchicolus*	(L/P)	C-MG/NF	11/1	1/Ø	3/Ø		
		Nanocladius sp. A	(P)	NF				1	
		Orthocladius obumbratus	(L/P)	C-MG/NF	4/Ø	2/Ø	12/Ø	162/3	2/Ø
		Orthocladius (*lapponicus*?)	(L)	C-MG			3	25	2
		Orthocladius (*manitobensis*?)	(P)	NF				3	1
		Orthocladius (subgenus *Euorthocladius*) sp.	(L/P)	C-MG/NF	30/2	1/Ø	1/Ø		
		Symbiocladius sp.	(L/P)	C-MG/NF			Ø/2		1/1
		Thienemanniella sp.	(L)	C-MG	6			1	3
		UID ORTHOCLADIINE PUPA A		NF				3	
		UID ORTHOCLADIINE PUPA B		NF	1	1			
		Diamesa sp. A	(L)	C-MG	6	2			
		Diamesa sp. B	(L)	C-MG			2		
	RHAGIONIDAE	*Atherix variegata*	(L)	P	19	49	8		
	TABANIDAE	UNIDENTIFIED SPECIES	(L)	P	32				
	EMPIDIDAE	*Chelifera* sp.	(L)	MP	1				
		Clinocera sp.	(L/P)	MP/NF		2/Ø	Ø/1		
		Hemerodromia sp. A	(L/P)	MP/NF		1/Ø	1/3		Ø/1
		Wiedemannia sp.	(L/P)	MP/NF			1/1		
ORGANISMS OTHER THAN INSECTS									
TRICLADIDA	PLANARIIDAE	*Polycelis coronata*		Sc	9	13			1
HOPLONEMERTEA	TETRASTEMMATIDAE	*Prostoma graecense*		MP					1
GORDIIDA	GORDIIDAE	*Gordius* sp.		NF				1	
HAPLOTAXIDA	NAIDIDAE	*Chaetogaster diaphanus*		MP			1		
		Nais behningi		C-MG	5		59		4
		N. communis		C-MG				112	
		N. pardalis		C-MG	2	3	20		23
		Pristina breviseta		C-MG				2	
		P. idrensis		C-MG			3		2
	TUBIFICIDAE	*Limnodrilus hoffmeisteri*		C-MG		1		3	18
	ENCHYTRAEIDAE	UID SPECIES A		C-MG	7	1			
		UID SPECIES B		C-MG				2	
	LUMBRICIDAE	UID SPECIES A		C-G	226	23	5	1	1
	ENCHYTRAEIDAE	*Mesenchytraeus* sp.		C-G	34				
LUMBRICULIDA	LUMBRICULIDAE	*Rhynchelmis rostrata*		C-G		2	5		
VENEROIDA	SPHAERIIDAE	UNIDENTIFIED (immature)		MF	1	1			

	Initials	Date
Prepared By		
Approved By		

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
SEPTEMBER, 1980
Page 1 of 4

INSECTS

ORDER	FAMILY	GENUS & SPECIES	TROPHIC HABITS	3 ° COMBINED SURBER SAMPLES — SAMPLING SITE: WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
EPHEMEROPTERA	HEPTAGENIIDAE	*Epeorus albertae*	S, C-G		3	4	3	
		Heptagenia criddlei	S, C-G			2		
		Rhithrogena morrisoni	S, C-G	16	22	45	1	29
	BAETIDAE	*Baetis bicaudatus*	C-G	33	18	11		101
		B. parvus	C-G		4	2		
		B. tricaudatus	C-G	17	17	11	10	83
	LEPTOPHLEBIIDAE	*Paraleptophlebia* sp. A	C-G	1		1		
		Paraleptophlebia sp. B	C-G			7		
	EPHEMERELLIDAE	*Ephemerella flavilinea*	C-G	1				
		E. grandis ingens	C-G	1	3	1		
		E. tibialis	C-G	47	24	17		1
		Ephemerella (SUBGENUS *Attenella*) sp. A	C-G		1			
	TRICORYTHIDAE	*Tricorythodes minutus*	C-G			2		18
ODONATA	GOMPHIDAE	UNIDENTIFIED SPECIES (IMMATURE)	P					1
	COENAGRIONIDAE	*Argia* sp.	P					4
PLECOPTERA	NEMOURIDAE	*Amphinemura* sp.	Sh	3	1			
	PTERONARCYIDAE	*Pteronarcys californica*	Sh, S	4	5	14		
		Pteronarcella badia	Sh, S		2			
	PERLODIDAE	*Cultus* sp.	P	2				
		Perlinodes aurea	P		4			
		Skwala sp.	P	11	5	16	4	16
		Isoperla sp.	P	1				
	PERLIDAE	*Calineuria californica*	P	3				
		Claassenia sabulosa	P	2	5	3		1
		Hesperoperla pacifica	P	3	1	8		
	CHLOROPERLIDAE	UID SPECIES	P	6	1			
TRICHOPTERA	RHYACOPHILIDAE	*Rhyacophila* sp. B (L)	P	3	5			
	GLOSSOSOMATIDAE	*Glossosoma traviatum* (L/P)	S/NF	27/4	117/30	15/20	Ø/1	1/Ø
		Protoptila coloma (L/P)	S/NF			64/Ø	Ø/1	1/21
	PHILOPOTAMIDAE	*Wormaldia gabriella* (L/P)	F/NF		3/Ø	3/4	7/Ø	4/Ø
	HYDROPSYCHIDAE	*Arctopsyche grandis* (L)	F	2	1			
		Cheumatopsyche sp. (L/P)	F/NF				31/1	183/2
		Hydropsyche occidentalis (L)	F			84		58
		Hydropsyche sp. A (L)	F				6	8
		Symphitopsyche sp. A (L)	F	81	60	3		
		Symphitopsyche sp. B (L)	F					54
		Symphitopsyche sp. C (L)	F		12	7		
	HYDROPTILIDAE	*Hydroptila* sp. (L/P)	S/NF	Ø/1				9/Ø
		Leucotrichia pictipes (L)	S					12

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
SEPTEMBER, 1980

	Initials	Date
Prepared By		
Approved By		

INSECTS

ORDER	FAMILY	GENUS & SPECIES		TROPHIC HABITS	3 Ø COMBINED SURBER SAMPLES – SAMPLING SITE: WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
TRICHOPTERA	BRACHYCENTRIDAE	Brachycentrus americanus	(L/P)	F, S/NF	330/Ø	101/3	Ø/2		
		Micrasema sp.	(L)	Sh	6				
	LEPIDOSTOMATIDAE	Lepidostoma sp. A	(L)	Sh	278	85	1		
		Lepidostoma sp. B	(L)	Sh	2				
	LIMNEPHILIDAE	Dicosmoecus gilvipes	(P)	NF	15	7	32		
		Neophylax rickeri	(P)	NF	28	2	1		
	LEPTOCERIDAE	Oecetis avara	(L)	P			6		16
	HELICOPSYCHIDAE	Helicopsyche borealis	(L)	S			253		6
LEPIDOPTERA	PYRALIDAE	Parargyractis sp.	(L)	F			2		1
COLEOPTERA	DYTISCIDAE	Oreodytes sp.	(L)	P	1				
	ELMIDAE	Cleptelmis sp.	(L)	S, C-G	1				
		Optioservus quadrimaculatus	(L/A)	S, C-G	83/38	26/27	37/1	4/2	67/9
		Ordobrevia nubifera	(L)	S, C-G			1		
		Zaitzevia parvula	(L/A)	S, C-G		Ø/1	2/Ø		1/2
		Narpus concolor	(L/A)	Sh	5/1	1/Ø			
DIPTERA	TIPULIDAE	Antocha sp.	(L/P)	C-G/NF	35/14	26/10	10/1		Ø/1
	PSYCHODIDAE	Pericoma sp.	(L)	C-G	7				
	SIMULIIDAE	Prosimulium sp.	(L)	MF		1			
		Simulium griseum	(L)	MF					1
	CHIRONOMIDAE	THIENEMANNIMYIA GROUP (UNIDENTIFIED)	(L/P)	MP/NF	4/Ø	3/Ø	1/Ø		4/1
		UID TANYPODINE PUPA B		NF					2
		UID TANYPODINE PUPA C		NF	1				
		Cladotanytarsus sp.	(L)	MF	1				3
		Micropsectra sp.	(L)	MF	25	70			
		Rheotanytarsus sp. A	(L/P)	MF/NF	9/1	13/1	103/4		7/1
		Rheotanytarsus sp. B	(L/P)	MF/NF	5/1				
		UID TANYTARSINI PUPA		NF	1				
		Microtendipes sp.	(L)	MF		1			2
		Polypedilum sp. A	(L/P)	MF/NF	44/3	41/3	63/3		189/20
		Cryptochironomus sp.	(L)	MP					1
		UID CHIRONOMINE PUPA B		NF					1
		UID CHIRONOMINE PUPA C		NF					1
		Brillia sp.	(L)	Sh	3				
		Corynoneura sp.	(L)	C-MG	5	2	2		
		Cricotopus sp. A (tremulus GROUP)	(L/P)	C-MG/NF	215/7	58/2	93/5		3/Ø
		Cricotopus sp. B (bicinctus GROUP)	(L/P)	C-MG/NF	5/Ø	1/Ø	50/5		1/Ø
		Eukiefferiella sp. A (bavarica GROUP)	(L)	C-MG	25	3	2		1
		Eukiefferiella sp. B (claripennis GROUP)	(L)	C-MG	10	11			
		Eukiefferiella sp. C (discoloripes GROUP)	(L/P)	C-MG/NF	44/Ø	16/Ø	13/1		2/Ø

4804 (84804) — Buff
8804 (88804) — Green

Made in U.S.A.

	Initials	Date
Prepared By		
Approved By		

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
SEPTEMBER, 1980
Page 3 of 4

INSECTS

ORDER	FAMILY	GENUS & SPECIES		TROPHIC HABITS	WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
					3D COMBINED SURBER SAMPLES — SAMPLING SITE				
DIPTERA	CHIRONOMIDAE	*Eukiefferiella* sp. D (potthastia group)	(L)	C-MG			1		6
		Heterotrissocladius sp.	(L)	C-MG	1	1			1
		Nanocladius spiniplenus	(L/P)	C-MG/NF	∅/1				2/1
		Orthocladius mallochi	(L/P)	C-MG/NF	304/61				
		O. manitobensis ?	(L/P)	C-MG/NF	3/7		3/1		110/13
		O. lapponicus ?	(L)	C-MG	2				
		O. obumbratus	(L)	C-MG		21	10	1	6
		Orthocladius (subgenus *Euorthocladius*) sp.	(L/P)	C-MG	51/1				
		Pseudosmittia sp.	(L)	C-MG					1
		Rheocricotopus sp.	(L)	C-MG	12	4			
		Synorthocladius sp.	(L)	C-MG		1			
		Thienemanniella sp.	(L/P)	C-MG/NF	19/2	2/1	9/2		14/2
		UID ORTHOCLADIINE PUPA A		NF					2
		Diamesa sp. B	(L)	C-MG	9	4			
		Pseudodiamesa sp.	(L)	C-MG	5	1			
		Sympotthastia sp.	(L/P)	C-MG/NF	15/2	2/1	2/∅		
	RHAGIONIDAE	*Atherix variegata*	(L)	P	5	1	4	9	
	TABANIDAE	UNIDENTIFIED SPECIES	(L)	P	11				
	EMPIDIDAE	*Chelifera* sp.	(L)	MP			2		
		Hemerodromia sp. A	(L/P)	MP/NF		1/∅	∅/1		2/1
		Hemerodromia sp. B	(P)	NF			2		
		Wiedemannia sp.	(L/P)	MP/NF			3/1		

Initials	Date
Prepared By	
Approved By	

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
SEPTEMBER, 1980
Page 4 of 4

ORGANISMS OTHER THAN INSECTS

ORDER	FAMILY	GENUS & SPECIES	TROPHIC HABITS	3° COMBINED SURBER SAMPLES — SAMPLING SITE: WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
TRICLADIDA	PLANARIIDAE	*Polycelis coronata*	Sc	4	8			31
MONOHYSTERIDA	LEPTOLAIMIDAE	*Leptolaimus* sp	C-MG	6				1
DORYLAIMIDA	DORYLAIMIDAE	*Oionchus* sp	C-MG	5				
HAPLOTAXIDA	NAIDIDAE	*Chaetogaster diaphanus*	MP			1		
		Nais behningi	C-MG	100	50			
		N. pardalis	C-MG			41		28
		Pristina breviseta	C-MG					13
		P. idrensis	C-MG			6		
	TUBIFICIDAE	UNIDENTIFIED SPECIES	C-MG	2				
	ENCHYTRAEIDAE	UID SPECIES A	C-MG	37				
	LUMBRICIDAE	UID SPECIES A	C-G	41	13	2		
	ENCHYTRAEIDAE	*Mesenchytraeus* sp.	C-G	1	2			
LUMBRICULIDA	LUMBRICULIDAE	*Rhynchelmis rostrata*	C-G	1	1			
ACARI	HYGROBATIDAE	*Megapella* sp.	U	1			2	
	HYDRYPHANTIDAE	*Protzia* sp.	U	6	1			
	SPERCHONTIDAE	*Sperchon* sp	U	7	3	1		
	TORRENTICOLIDAE	*Torrenticola* sp.	U	5				
VENEROIDA	SPHAERIIDAE	UNIDENTIFIED (IMMATURE)	MF	4	2			
BASOMMATOPHORA	ANCYLIDAE	*Ferrissia* sp.	S				1	

4804 (84804) — Buff
8804 (88804) — Green

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
JUNE-JULY, 1980

Prepared By	Initials	Date
Approved By		

INSECTS

ORDER	FAMILY	GENUS & SPECIES	TROPHIC HABITS	12° COMBINED SURBER SAMPLES — SAMPLING SITE: WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
EPHEMEROPTERA	HEPTAGENIIDAE	*Cinygmula* sp.	S, C-G	53	4	1		
		Epeorus albertae	S, C-G		15	32		
		E. longimanus	S, C-G	9				
		Heptagenia criddlei	S, C-G			33	2	
		H. simplicioides	S, C-G				6	9
		Rhithrogena morrisoni	S, C-G		2	6	1	21
	BAETIDAE	*Baetis bicaudatus*	C-G	3	11	25	4	232
		B. tricaudatus	C-G	18	14	10	15	589
	LEPTOPHLEBIIDAE	*Paraleptophlebia* sp. A	C-G	27	7	11		
	EPHEMERELLIDAE	*Ephemerella doddsi*	P, C-G	2				
		E. flavilinea	C-G	21	8	4		
		E. grandis ingens	C-G	3				
		E. heterocaudata	C-G	26				
		E. infrequens	C-G	23				
		E. tibialis	C-G	1	1	32		
		Ephemerella (subgenus *Attenella*) sp. A	C-G			60		
	TRICORYTHIDAE	*Tricorythodes minutus*	C-G				1	16
PLECOPTERA	PTERONARCYIDAE	*Pteronarcys californica*	Sh, S	6	11	25	1	4
		Pteronarcella badia	Sh, S	1		17		6
	PERLODIDAE	*Kogotus* sp.	P, S	7				
		Skwala sp.	P		1	30	3	55
	PERLIDAE	*Calineuria californica*	P	2	2			
		Claassenia sabulosa	P	10	1	11	11	10
		Hesperoperla pacifica	P	18	1	1		
TRICHOPTERA	RHYACOPHILIDAE	*Rhyacophila insularis* (P)	NF			1		
		Rhyacophila sp. A (acropedes Group) (L)	P	1				
	GLOSSOSOMATIDAE	*Glossosoma traviatum* (L/P)	S/NF	5/3	8/26	37/77	4/0	1/0
		G. pterna (L/P)	S/NF		6/11			
		Protoptila coloma (L/P)	S/NF			2/3	2/3	6/2
	PHILOPOTAMIDAE	*Wormaldia gabriella* (L/P)	F/NF			65/2	1/0	2/0
	HYDROPSYCHIDAE	*Cheumatopsyche* sp. (L/P)	F/NF				14/0	1/0
		Hydropsyche occidentalis (L/P)	F/NF		3/0	321/25	42/1	
		Hydropsyche sp. A (L/P)	F/NF				1/0	68/3
		Symphitopsyche sp. A (L/P)	F/NF	59/5	19/8			
		Symphitopsyche sp. B (L/P)	F/NF					9/6
	HYDROPTILIDAE	*Hydroptila* sp. (L)	S					1
		Leucotrichia pictipes (L)	S					1
	BRACHYCENTRIDAE	*Brachycentrus americanus* (L/P)	F, S/NF	134/5	138/10	428/1	1/0	7/0
		Micrasema sp. (L)	Sh	1				

	Initials	Date
Prepared By		
Approved By		

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
JUNE-JULY, 1980
Page 2 of 3

INSECTS

ORDER	FAMILY	GENUS & SPECIES		TROPHIC HABITS	12° COMBINED SURBER SAMPLES – SAMPLING SITE: WOOTEN	HARHERY	MARENGO	KROUSE	FLETCHER
TRICHOPTERA	LEPIDOSTOMATIDAE	Lepidostoma sp. A	(L/P)	Sh	31/11	5/23			
		Lepidostoma sp. B	(L)	Sh	2				
	LIMNEPHILIDAE	Dicosmoecus gilvipes	(L)	S	17	10	11		
		Neophylax rickeri	(L/P)	S/NF	9/3	Ø/1			
		Onocosmoecus sp.	(L)	Sh	2				
	LEPTOCERIDAE	Oecetis avara	(L)	P			16	3	1
	HELICOPSYCHIDAE	Helicopsyche borealis	(L/P)	S/NF			51/Ø	2/1	
LEPIDOPTERA	PYRALIDAE	Paragyractis sp.	(L)	F					1
COLEOPTERA	ELMIDAE	Cleptelmis sp.	(L)	S, C-G	2				
		Optioservus quadrimaculatus	(L/A)	S, C-G	13/74	14/74	36/10	7/4	13/44
		Ordobrevia nubifera	(A)	S, C-G	1		2		
		Zaitzevia parvula	(L/A)	S, C-G	Ø/1		Ø/2	Ø/2	2/3
		Narpus concolor	(L/A)	Sh	8/1	5/Ø	2/Ø	1/Ø	
DIPTERA	TIPULIDAE	Antocha sp.	(L/P)	C-G/NF	20/2	8/2	5/Ø	1/Ø	
		Hexatoma sp.	(L)	P	1/Ø	Ø/1			
	TANYDERIDAE	Protanyderus sp.	(L)	U			1	1	
	SIMULIIDAE	Simulium griseum	(L/P)	MF/NF			2/Ø	3/Ø	5/2
	CHIRONOMIDAE	Pentaneura sp.	(L)	MP			1		
		Thienemannimyia GROUP (UID)	(L/P)	MP/NF	1/Ø		3/1		1/2
		UID TANYPODINE PUPA A		NF			1		2
		Cladotanytarsus sp.	(L/P)	MF/NF		9/Ø	1/Ø		1/1
		Micropsectra sp.	(L/P)	C-MG/NF	3/Ø	2/Ø	3/1	1/Ø	1/1
		Rheotanytarsus sp. A	(L/P)	MF/NF	Ø/1		9/Ø	3/1	4/7
		Cryptochironomus sp.	(L)	MP		1			
		Demicryptochironomus sp.	(L/P)	C-MG/NF					1/2
		Microtendipes sp.	(L)	MF	5	1			
		Phaenopsectra sp.	(L)	C-MG				1	
		Polypedilum sp. A	(L/P)	MF/NF	11/Ø	1/Ø	97/11	5/1	267/9
		Polypedilum sp. B	(L)	MF				6	
		UID CHIRONOMINE PUPA A		NF					1
		Brillia sp.	(L)	Sh			1		
		Corynoneura sp.	(L)	C-MG				1	
		Cricotopus sp. A (tremulus group)	(L)	C-MG	13	34	17		
		Cricotopus sp. B (bicinctus group)	(L)	C-MG				54	2
		Eukiefferiella sp. A (bavarica group)	(L/P)	C-MG/NF	2/Ø		3/1		2/Ø
		Eukiefferiella sp. B (claripennis group)	(L/P)	C-MG/NF		1/Ø	38/5	43/4	2/Ø
		Eukiefferiella sp. C (discoloripes group)	(L/P)	C-MG/NF	1/1	2/2	10/Ø	1/Ø	1/Ø
		Eukiefferiella sp. D (potthastia group)	(L)	C-MG			9	5	4
		Heterotrissocladius sp.	(L/P)	C-MG/NF	Ø/1		Ø/1	1/Ø	

Prepared By
Approved By

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
JUNE – JULY, 1980
Page 3 of 3

INSECTS

ORDER	FAMILY	GENUS & SPECIES		TROPHIC HABITS	12° COMBINED SURBER SAMPLES — SAMPLING SITE: WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
DIPTERA	CHIRONOMIDAE	Nanocladius branchicolus	(L/P)	C-MG/NF	11/1	1/Ø	3/Ø		
		Nanocladius sp. A	(P)	NF				1	
		Orthocladius obumbratus	(L/P)	C-MG/NF	4/Ø	2/Ø	12/Ø	162/3	2/Ø
		Orthocladius (lapponicus?)	(L)	C-MG			3	25	2
		Orthocladius (manitobensis?)	(P)	NF				3	1
		Orthocladius (SUBGENUS Euorthocladius) sp.	(L/P)	C-MG/NF	30/2	1/Ø	1/Ø		
		Symbiocladius sp	(L/P)	C-MG/NF			Ø/2		1/1
		Thienemanniella sp.	(L)	C-MG	6			1	3
		UID ORTHOCLADIINE PUPA A		NF				3	
		UID ORTHOCLADIINE PUPA B		NF	1	1			
		Diamesa sp. A	(L)	C-MG	6	2			
		Diamesa sp B	(L)	C-MG			2		
	RHAGIONIDAE	Atherix variegata	(L)	P	19	49	8		
	TABANIDAE	UNIDENTIFIED SPECIES	(L)	P	32				
	EMPIDIDAE	Chelifera sp.	(L)	MP	1				
		Clinocera sp.	(L/P)	MP/NF		2/Ø	Ø/1		
		Hemerodromia sp A	(L/P)	MP/NF		1/Ø	1/3		Ø/1
		Wiedemannia sp	(L/P)	MP/NF			1/1		

ORGANISMS OTHER THAN INSECTS

ORDER	FAMILY	GENUS & SPECIES	TROPHIC HABITS	WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
TRICLADIDA	PLANARIIDAE	Polycelis coronata	Sc	9	13			1
HOPLONEMERTEA	TERTASTEMMATIDAE	Prostoma graecense	MP					1
GORDIIDA	GORDIIDAE	Gordius sp.	NF				1	
HAPLOTAXIDA	NAIDIDAE	Chaetogaster diaphanus	MP			1		
		Nais behningi	C-MG	5		59		4
		N. communis	C-MG				112	
		N. pardalis	C-MG	2	3	20		23
		Pristina breviseta	C-MG				2	
		P. idrensis	C-MG			3		2
	TUBIFICIDAE	Limnodrilus hoffmeisteri	C-MG		1		3	18
	ENCHYTRAEIDAE	UID SPECIES A	C-MG	7	1			
		UID SPECIES B	C-MG				2	
	LUMBRICIDAE	UID SPECIES A	C-G	226	23	5	1	1
	ENCHYTRAEIDAE	Mesenchytraeus sp.	C-G	34				
LUMBRICULIDA	LUMBRICULIDAE	Rhynchelmis rostrata	C-G		2	5		
VENEROIDA	SPHAERIIDAE	UNIDENTIFIED (immature)	MF	1	1			

4804 (84804) — Buff
8804 (88804) — Green

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
SEPTEMBER, 1980
Page 1 of 4

Prepared by	Initials	Date
Approved by		

INSECTS

ORDER	FAMILY	GENUS & SPECIES	TROPHIC HABITS	3 ft² COMBINED SURBER SAMPLES — SAMPLING SITE: WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
EPHEMEROPTERA	HEPTAGENIIDAE	*Epeorus albertae*	S, C-G		3	4	3	
		Heptagenia criddlei	S, C-G			2		
		Rhithrogena morrisoni	S, C-G	16	22	45	1	29
	BAETIDAE	*Baetis bicaudatus*	C-G	33	18	11		101
		B. parvus	C-G		4	2		
		B. tricaudatus	C-G	17	17	11	10	83
	LEPTOPHLEBIIDAE	*Paraleptophlebia* sp. A	C-G	1		1		
		Paraleptophlebia sp. B	C-G			7		
	EPHEMERELLIDAE	*Ephemerella flavilinea*	C-G	1				
		E. grandis ingens	C-G	1	3	1		
		E. tibialis	C-G	47	24	17		1
		Ephemerella (subgenus *Attenella*) sp. A	C-G		1			
	TRICORYTHIDAE	*Tricorythodes minutus*	C-G			2		18
ODONATA	GOMPHIDAE	UNIDENTIFIED SPECIES (IMMATURE)	P					1
	COENAGRIONIDAE	*Argia* sp.	P					4
PLECOPTERA	NEMOURIDAE	*Amphinemura* sp.	Sh	3	1			
	PTERONARCYIDAE	*Pteronarcys californica*	Sh, S	4	5	14		
		Pteronarcella badia	Sh, S		2			
	PERLODIDAE	*Cultus* sp.	P	2				
		Perlinodes aurea	P		4			
		Skwala sp.	P	11	5	16	4	16
		Isoperla sp.	P	1				
	PERLIDAE	*Calineuria californica*	P	3				
		Claassenia sabulosa	P	2	5	3		1
		Hesperoperla pacifica	P	3	1	8		
	CHLOROPERLIDAE	UID SPECIES	P	6	1			
TRICHOPTERA	RHYACOPHILIDAE	*Rhyacophila* sp. B (L)	P	3	5			
	GLOSSOSOMATIDAE	*Glossosoma traviatum* (L/P)	S/NF	27/4	117/30	15/20	Ø/1	1/Ø
		Protoptila coloma (L/P)	S/NF			64/Ø	Ø/1	1/21
	PHILOPOTAMIDAE	*Wormaldia gabriella* (L/P)	F/NF		3/Ø	3/4	7/Ø	4/Ø
	HYDROPSYCHIDAE	*Arctopsyche grandis* (L)	F	2	1			
		Cheumatopsyche sp. (L/P)	F/NF				31/1	183/2
		Hydropsyche occidentalis (L)	F			84		58
		Hydropsyche sp. A (L)	F				6	8
		Symphitopsyche sp. A (L)	F	81	60	3		
		Symphitopsyche sp. B (L)	F					54
		Symphitopsyche sp. C (L)	F		12	7		
	HYDROPTILIDAE	*Hydroptila* sp. (L/P)	S/NF	Ø/1				7/Ø
		Leucotrichia pictipes (L)	S					12

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
SEPTEMBER, 1980
Page 2 of 4

Prepared by | Approved by | Initial | Date

INSECTS

3 ft² COMBINED SURBER SAMPLES — SAMPLING SITE

ORDER	FAMILY	GENUS & SPECIES		TROPHIC HABITS	WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
TRICHOPTERA	BRACHYCENTRIDAE	Brachycentrus americanus	(L/P)	F, S/NF	330/ø	101/3	ø/2		
		Micrasema sp.	(L)	Sh	6				
	LEPIDOSTOMATIDAE	Lepidostoma sp. A	(L)	Sh	278	85	1		
		Lepidostoma sp. B	(L)	Sh	2				
	LIMNEPHILIDAE	Dicosmoecus gilvipes	(P)	NF	15	7	32		
		Neophylax rickeri	(P)	NF	28	2	1		
	LEPTOCERIDAE	Oecetis avara	(L)	P			6		16
	HELICOPSYCHIDAE	Helicopsyche borealis	(L)	S			253		6
LEPIDOPTERA	PYRALIDAE	Parargyractis sp.	(L)	F			2		1
COLEOPTERA	DYTISCIDAE	Oreodytes sp.	(L)	P	1				
	ELMIDAE	Cleptelmis sp.	(L)	S, C-G	1				
		Optioservus quadrimaculatus	(L/A)	S, C-G	83/38	26/27	37/1	4/2	67/9
		Ordobrevia nubifera	(L)	S, C-G			1		
		Zaitzevia parvula	(L/A)	S, C-G		ø/1	2/ø		1/2
		Narpus concolor	(L/A)	Sh	5/1	1/ø			
DIPTERA	TIPULIDAE	Antocha sp.	(L/P)	C-G/NF	35/14	26/10	10/1		ø/1
	PSYCHODIDAE	Pericoma sp.	(L)	C-G	7				
	SIMULIIDAE	Prosimulium sp.	(L)	MF		1			
		Simulium griseum	(L)	MF					1
	CHIRONOMIDAE	THIENEMANNIMYIA GROUP (UNIDENTIFIED)	(L/P)	MP/NF	4/ø	3/ø	1/ø		4/1
		UID TANYPODINE PUPA B		NF					2
		UID TANYPODINE PUPA C		NF	1				
		Cladotanytarsus sp.	(L)	MF	1				3
		Micropsectra sp.	(L)	MF	25	70			
		Rheotanytarsus sp. A	(L/P)	MF/NF	9/1	13/1	103/4		7/1
		Rheotanytarsus sp. B	(L/P)	MF/NF	5/1				
		UID TANYTARSINI PUPA		NF	1				
		Microtendipes sp.	(L)	MF		1			2
		Polypedilum sp. A	(L/P)	MF/NF	44/3	41/3	63/3		180/20
		Cryptochironomus sp.	(L)	MP					1
		UID CHIRONOMINE PUPA B		NF					1
		UID CHIRONOMINE PUPA C		NF					1
		Brillia sp.	(L)	Sh	3				
		Corynoneura sp.	(L)	C-MG	5	2	2		
		Cricotopus sp. A (tremulus grp)	(L/P)	C-MG/NF	215/7	58/2	93/5		3/ø
		Cricotopus sp. B (bicinctus group)	(L/P)	C-MG/NF	5/ø	1/ø	50/5		11/ø
		Eukiefferiella sp. A (bavarica group)	(L)	C-MG	25	3	2		1
		Eukiefferiella sp. B (claripennis group)	(L)	C-MG	10	11			
		Eukiefferiella sp. C (discoloripes group)	(L/P)	C-MG/NF	44/ø	16/ø	13/1		2/ø

Made in U.S.A.

4804 (84804) — Buff
8804 (88804) — Green

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
SEPTEMBER, 1980

	Initials	Date
Prepared By		
Approved By		

INSECTS

ORDER	FAMILY	GENUS & SPECIES		TROPHIC HABITS	WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
					3° COMBINED SURBER SAMPLES – SAMPLING SITE				
DIPTERA	CHIRONOMIDAE	*Eukiefferiella* sp. D (*potthastia* group)	(L)	C-MG			1		6
		Heterotrissocladius sp.	(L)	C-MG	1	1			1
		Nanocladius spiniplenus	(L/P)	C-MG/NF	ø/1				2/1
		Orthocladius mallochi	(L/P)	C-MG/NF	304/61				
		O. manitobensis ?	(L/P)	C-MG/NF	3/7		3/1		110/13
		O. lapponicus ?	(L)	C-MG	2				
		O. obumbratus	(L)	C-MG		21	10	1	6
		Orthocladius (subgenus *Euorthocladius*) sp.	(L/P)	C-MG	51/1				
		Pseudosmittia sp.	(L)	C-MG					1
		Rheocricotopus sp.	(L)	C-MG	12	4			
		Synorthocladius sp.	(L)	C-MG		1			
		Thienemanniella sp.	(L/P)	C-MG/NF	19/2	2/1	9/2		14/2
		UID ORTHOCLADIINE PUPA A		NF					2
		Diamesa sp. B	(L)	C-MG	9	4			
		Pseudodiamesa sp.	(L)	C-MG	5	1			
		Sympotthastia sp.	(L/P)	C-MG/NF	15/2	2/1	2/ø		
	RHAGIONIDAE	*Atherix variegata*	(L)	P	5	1	4	9	
	TABANIDAE	UNIDENTIFIED SPECIES	(L)	P	11				
	EMPIDIDAE	*Chelifera* sp.	(L)	MP			2		
		Hemerodromia sp. A	(L/P)	MP/NF		1/ø	ø/1		2/1
		Hemerodromia sp. B	(P)	NF			2		
		Wiedemannia sp.	(L/P)	MP/NF			3/1		

4804 (84804) — Buff
8804 (88804) — Green

Made in U.S.A.

HYDROZOOLOGY

TUCANNON RIVER BENTHOS
SEPTEMBER, 1980
Page 4 of 4

Prepared By	
Approved By	

ORGANISMS OTHER THAN INSECTS

ORDER	FAMILY	GENUS & SPECIES	TROPHIC HABITS	3° COMBINED SURBER SAMPLES — SAMPLING SITE: WOOTEN	HATCHERY	MARENGO	KROUSE	FLETCHER
TRICLADIDA	PLANARIIDAE	*Polycelis coronata*	Sc	4	8			31
MONOHYSTERIDA	LEPTOLAIMIDAE	*Leptolaimus* sp	C-MG	6				1
DORYLAIMIDA	DORYLAIMIDAE	*Oionchus* sp	C-MG	5				
HAPLOTAXIDA	NAIDIDAE	*Chaetogaster diaphanus*	MP			1		
		Nais behningi	C-MG	100	50			
		N. pardalis	C-MG			41		28
		Pristina breviseta	C-MG					13
		P. idrensis	C-MG			6		
	TUBIFICIDAE	UNIDENTIFIED SPECIES	C-MG	2				
	ENCHYTRAEIDAE	UID SPECIES A	C-MG	37				
	LUMBRICIDAE	UID SPECIES A	C-G	41	13	2		
	ENCHYTRAEIDAE	*Mesenchytraeus* sp.	C-G	1	2			
LUMBRICULIDA	LUMBRICULIDAE	*Rhynchelmis rostrata*	C-G	1	1			
ACARI	HYGROBATIDAE	*Megapella* sp.	U	1			2	
	HYDRYPHANTIDAE	*Protzia* sp.	U	6	1			
	SPERCHONTIDAE	*Sperchon* sp	U	7	3	1		
	TORRENTICOLIDAE	*Torrenticola* sp.	U	5				
VENEROIDA	SPHAERIIDAE	UNIDENTIFIED (IMMATURE)	MF	4	2			
BASOMMATOPHORA	ANCYLIDAE	*Ferrissia* sp.	S				1	

Made in U S A

TOTAL POPULATION

The total numbers and weight of invertebrates per square foot of bottom in the Tucannon River compares favorably with most other streams where comparable data has been gathered (table 16). We removed all caddisfly larva from their cases before measuring volumes and converting to weight but do not know if that was done with the collections from elsewhere.

The number of invertebrates per square foot increased in a normal fashion during the summer at every station except Krouse's where it fell (fig. 14). The biomass also increased everywhere except at Krouse's and at Fletcher's, where it remained about the same. We do not have any explanation for the lack of an increase at Krouse's, other than that the substrate there was more mobile and continued shifting even at relatively low flows. The failure of the biomass at Fletcher's Station to increase was because the relatively large baetid mayfly *Baetis tricaudatis* captured in such large numbers in July, had greatly declined in abundance by the September sampling.

The Tucannon River invertebrate fauna had a high diversity at all stations and during both sampling periods (table 15).

Table 15. Number of invertebrate species collected at five stations along the Tucannon River in 1980.

	Wooten	Hatchery	Marengo	Krouse	Fletcher	Totals
JUNE - JULY - 12 SURBER SAMPLES						
TOTAL SPECIES	59	48	61	47	49	112
Insect species	52	41	55	41	42	96
Other species	7	7	6	6	7	16
SEPTEMBER - 3 SURBER SAMPLES						
TOTAL SPECIES	75	59	55	14	51	119
Insect species	61	51	50	12	47	100
Other species	14	8	5	2	4	19

Table 16. Comparison of total number and wet weight of benthic invertebrates in the Tucannon and other rivers.

RIVER	Numbers/sq.foot JULY	Numbers/sq.foot Sept.	Grams/sq.foot Summer average	Reference
Tucannon River	92	375	1.72/1	(Kelley & Assoc. 81)
West Creek, Quebec	289	---	1.03	(Mackay & Kalff, 69)
Oswegatechie R., NY	---	---	0.67	(Pate, 32)
Black River, NY	---	---	1.02	"
Big Springs, VA	---	---	5.05	(Surber, 37)
Firehole R., Wyoming	113	---	0.92	(Armitage, 58)
Afon Hernaut, Wales	---	---	0.28	(Hynes, 61)
Doc Run, Kentucky	263	---	1.06	(Minkley, 63)
River Endrich, Scot.	2508	---	1.49	(Maitland, 66)
Convict Cr., CA	136	151	0.81	(Kennedy, 67)
Control Cr., Idaho	111	107	----	(Hart & Brusven, 76)
Cabin Cr., Idaho	88	244	----	"
Ditch Cr., Idaho	57	97	----	"
Eggers Cr., Idaho	73	154	----	"
D Creek, Idaho	54	105	----	"
C Creek, Idaho	84	123	----	"
Silver Creek, Idaho	98	183	----	"
White River and War Eagle Cr., Arkansas	653	320	----	" (Aggus & Warren, 65)
Old Field, NC	113	---	----	(Woodall & Wallace72)
Hardwood, NC	75	---	----	"
White Pine, NC	66	---	----	"
Coppia, NC	73	---	----	"

/1 Caddisfly cases removed.

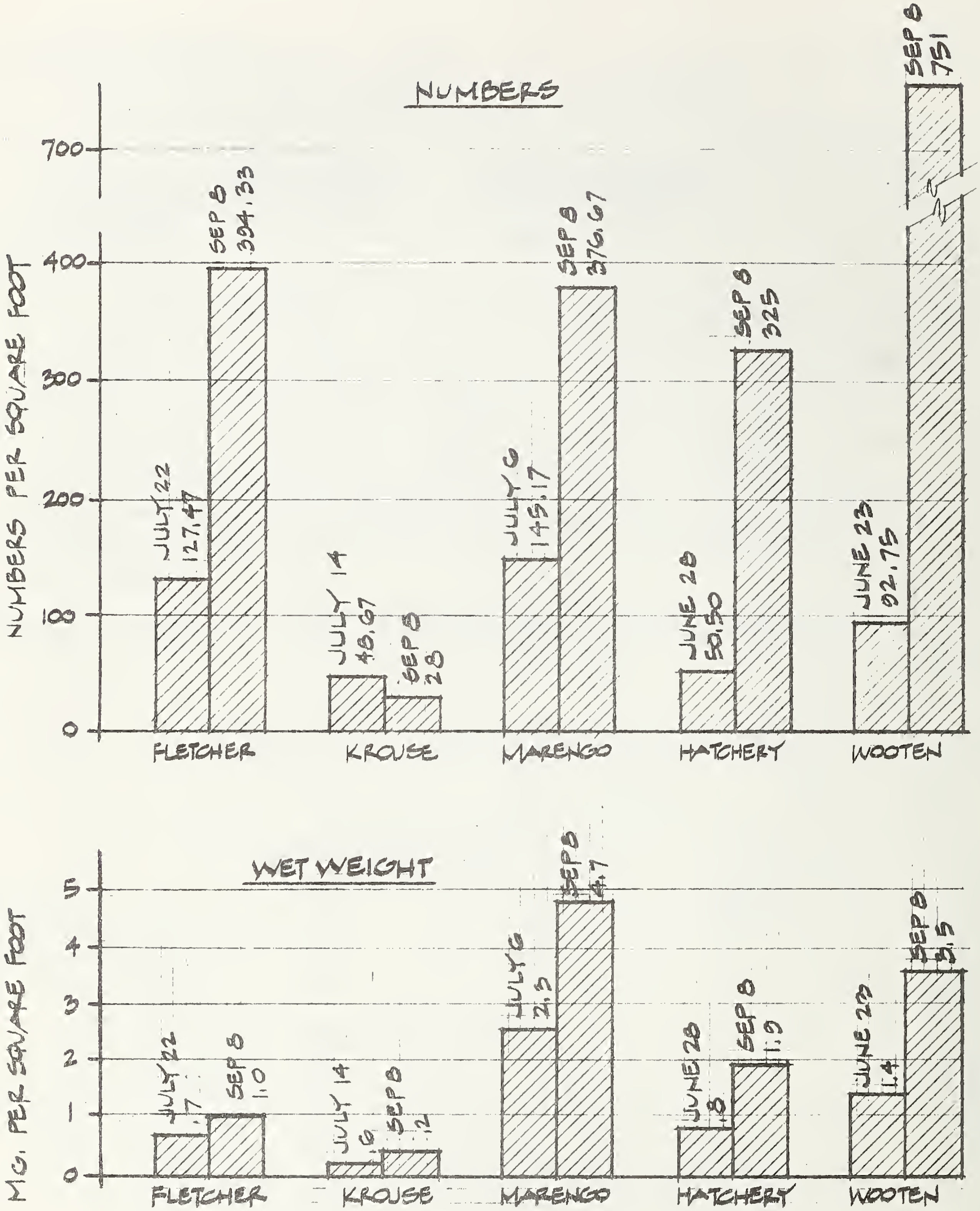


Figure 14. Total numbers and wet weight of aquatic invertebrates per square foot of the Tucannon River bottom, summer and fall, 1980.

Fields identified 149 species of invertebrates from these samples and, except that stone flies were relatively scarce, the fauna is what we would have expected to find here. About one-third of the species were found only at a single station. Only 19% were found at both the most upstream and downstream stations, Wooten and Fletcher.

INTERPRETATION OF INVERTEBRATE COLLECTION

Over the years, many attempts have been made to assess the meaning of data from invertebrate collections. It is easy to collect a very large amount of benthic organisms, harder to properly identify them, and very difficult to interpret the data and relate it to ecological conditions, fish growth, etc.

We like the approach of Cummins (1974), and others who have assessed the benthic fauna in terms of how the different species feed and what they eat. Cummins uses four major categories--shredders, collectors, scrapers, and predators. We added a category of nonfeeding adults and/or pupa as nonfeeders, and Fields classified our benthic collections according to their food habits.

Our divisions of the invertebrates based on their food habits is, of course, only as good as our assessment of what they eat. Unfortunately, there is not a lot of information available on this and, of course, many eat several different kinds of food. For example, the caddisfly larva Brachycentrus americanus will scrape periphyton off the rocks, but will also use the setae (hairs on their legs) to filter organic particles out of the current. They are scrapers and filterers (collectors in Cummins system) at the same time. For such opportunistic gourmands, we divided their numbers equally into the different categories for which they qualified.

Shredders

Shredders feed on coarse particulate organic matter (CPOM) which is defined as organic particles greater than 1 mm. in diameter. CPOM is represented in the stream by leaves and conifer needles, twigs, branches, bark, nuts, fruits, and flowers.

The numbers of shredders showed a striking decline from the uppermost to the lower stations (fig. 12) probably reflecting the reduced amount of CPOM in the stream as it moves from the forest to the farmland. The principal shredder was the caddisfly larva Lepidostoma sp.

Collectors

Collectors feed on fine particulate organic matter (FPOM) which is defined as organic particles smaller than 1 mm. in diameter. Collectors usually feed on material that has been broken down by shredders, or on FPOM from other sources being carried by the stream. Fields divides this group into four subgroups based upon size and manner of collecting FPOM. His groups are: collector/gatherer, collector/microgatherer, filterer, and microfilterer. Filterers collect FPOM from either structures on their bodies or by silken nets that they weave. Collector/gatherers are more generalized. The principal collector/gatherers were the baetid and ephemerellid mayflies, various web spinning caddisflies, and several species of chironomids and oligochaetes that collect and gather finer organic material. Collector/gatherers made up 45-90% of the benthic invertebrates in our collection and were especially abundant in the lower river (fig. 15).

Scrapers

Scrapers are animals especially adapted for removing attached algae (periphyton) from the exposed surfaces. In general, they were the second most abundant trophic level in the Tucannon River and, like shredders, were much more abundant in the upper three stations than in the lower two.

We found no relationship at all between the numbers of scrapers or the percentage of them in the invertebrate population and total periphyton at the various stations, but a definite relationship between the abundance of scrapers and the percent of periphyton which was organic matter (table 17).

Table 17. Comparison of organic composition of periphyton and percent invertebrate population that were scrapers, Tucannon River 1980.

STATION AND SAMPLE		MEAN % ORGANIC MATTER OF PERIPHYTON	INVERTEBRATES WITH SCRAPING FEEDING HABITS
JULY	Wooten	64.24	16.53
	Hatchery	66.43	25.08
	Marengo	46.76	22.27
	Krouse	7.25	3.42
	Fletcher	11.79	3.30
SEPT.	Wooten	39.06	11.67
	Hatchery	46.58	21.28
	Marengo	49.97	33.98
	Krouse	31.84	4.76
	Fletcher	21.47	6.80

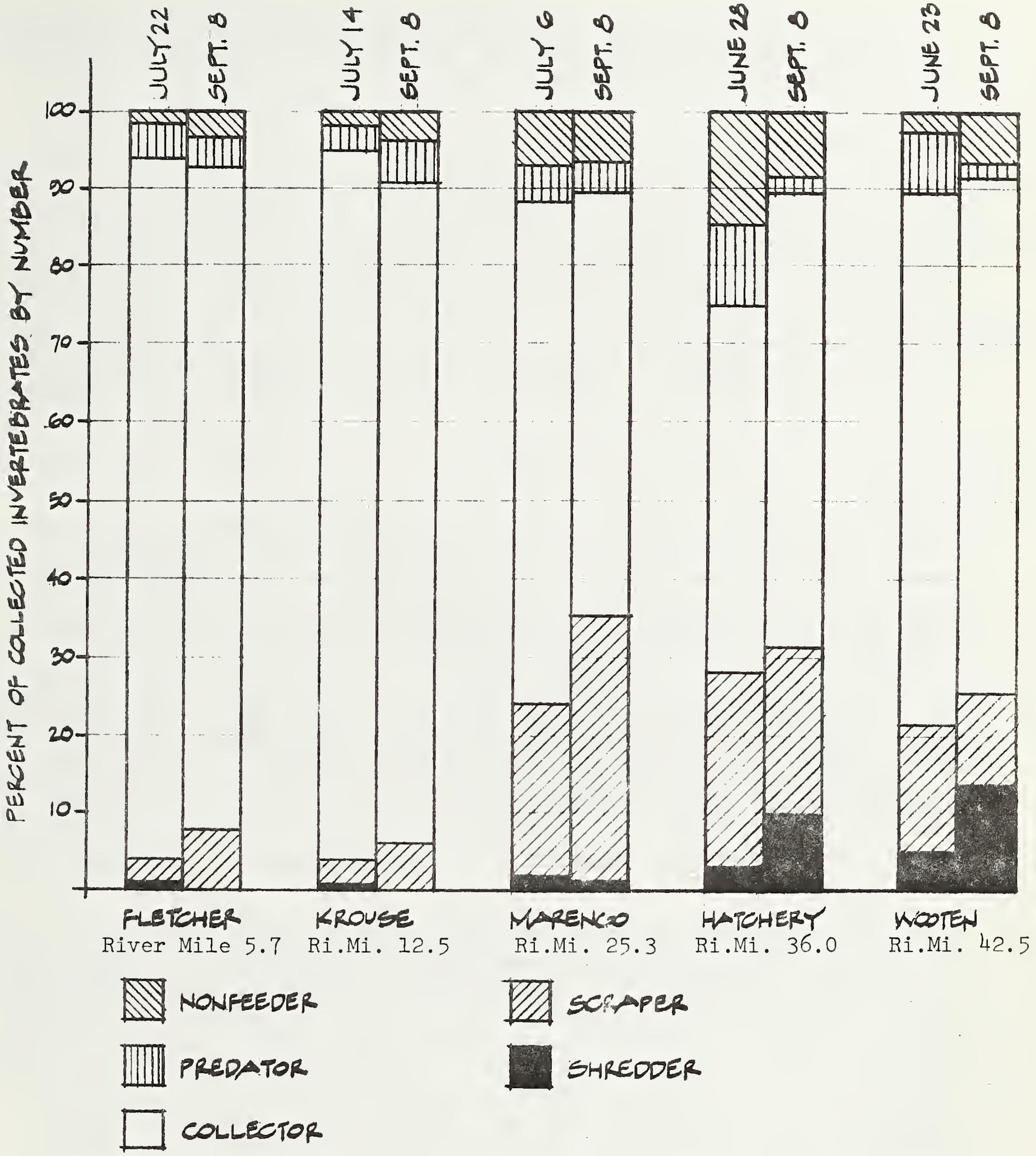


Figure 15. Food habits of benthic invertebrates collected within the Tucannon River. Based on 60 Surber samples collected in June-July, and 15 collected in September, 1980. Individuals were assigned to food habit categories by W. C. Fields of Hydrozoology, based on Merritt and Cummins (1978) and other sources.

The principal scrapers were several species of mayflies and elmid beetles. All collect and gather material as well as scraping it from the rocks.

Predators

Predators eat other animals. Fields divides this group based on size, calling the small organisms, micropredators. Predators were never abundant at any station. Most were stoneflies which seemed scattered in small numbers throughout the river. A larger percentage of invertebrates in the June collections were predators, primarily because those collections contained large numbers of the snipe fly larva *Atherix variegata*, and an unidentified horsefly larva. The numbers of those two insects were much less when Dr. Li sampled again in September.

CONCLUSIONS ABOUT INVERTEBRATES

Except for the scarcity of snails and stoneflies, we found little unusual in the collections. We collected no snails and only a single limpid. Snails are scrapers and are strongly associated with periphyton. W. C. Fields hypothesizes that the high stream velocities and, possibly, fine sediment may constrain snail populations.

The role of the snail has been taken by the larvae of the caddisfly *Helicopsyche borealis* at Marengo. This caddisfly larva looks like a snail and eats like a snail, but is able to use its claws to cling to rough or sediment covered substrates in fast flows where snails cannot go.

Stoneflies were probably discouraged by the high water temperatures.

Analysis of stream benthic populations based on feeding habitat is relatively new and we were unable to find much data from other streams. The population of shredders we found on the Tucannon River was similar to Minshall's (1981) findings on Mink Creek, a small, hardwater, third order stream, in Idaho, but differed from those found by Anderson and Sedell (1979) on a smaller third order stream in Oregon (table 18). This is probably because the amount of CPOM in Mink Creek was more similar to the Tucannon. Third order, or heavily forested, streams usually obtain most of their energy from leaf fall and need large numbers of shredders to begin the process. In the Tucannon, shredders decreased and collectors increased in the downstream direction as expected with the decomposition of CPOM to FPOM.

Table 18. Comparative food habits of aquatic invertebrate communities in the Tucannon River, 1980, and two other streams. Figures are percent of total population.

LOCATION	Shredder	Scraper	Collector	Predator	Other	SOURCE
Tucannon River, WA						This study
July	1.68	14.42	72.85	5.53	5.52	
Sept	7.20	17.09	66.54	2.55	6.62	
Mink Cr., ID						Minshall,'81.
1968-1969	1.70	41.80	50.40	5.30	.9	
1969-1970	2.60	32.80	59.70	2.80	2.2	
3rd Order stream, OR	25	25	40	10		Anderson & Sedell, 1979

Collector/gatherers made up a higher proportion of the Tucannon River population primarily because of the lack of scrapers there. We found scrapers abundant upstream, but greatly reduced in the lower two stations where periphyton had a low organic content. That may be the result of outflows from Willow Creek and Pataha Creek, both of which flow through areas of farmed hillsides. The high level of inorganics would be abrasive to scraper's mouth parts, and may make the periphyton unpalatable. The sediment from the Willow Creek flash flood in June reduced the numbers and diversity of aquatic invertebrates at Krouse.

Comparison with invertebrate populations elsewhere suggests that there are enough invertebrates to provide an abundant food supply for young fish. The biovolumes were exceptionally high.

CHAPTER VI. FISHES

Fish populations were sampled, first with a backpack shocker to find what species were living in various reaches of the Tucannon River, and then with a more powerful shocker to make the population estimates needed to calibrate our assessments of the quantity and quality of juvenile salmonid rearing habitat. With the backpack shocker, Dr. Li and others sampled small side channels and edges of the main stream in 19 areas spread from above Camp Wooten to below Fletchers. This sampling extended from mid-July to mid-September, but most was completed by mid-August.

Both young-of-the-year and yearling steelhead (or rainbow trout) and young-of-the-year chinook salmon were common in such habitat down to the Marengo reach, but we were able to collect only a few below Marengo. At Marengo, we found young-of-the-year steelhead but no yearlings and no salmon. Even young-of-the-year steelhead became difficult to locate as water temperatures rose in August. Because of this we selected 10 reaches upstream, where high water temperature was not a problem, to make the population estimates needed for calibration of our river-long assessments of physical habitat.

The reconnaissance level backpack shocking led us to conclude that sculpins were abundant in the upper river, and that below Marengo they were gradually replaced with speckled and longnosed dace, squawfish, and suckers. In the lower river at Fletcher's, we also found chiselmouth.

Between August 25 and 29, with help from the USCS and University of Idaho staffs, we estimated the fish populations of two pools, four glides, and four riffles in the Wooten and Hatchery area. The estimates were based on diminishing catches of each species from three (in one case, two) passes of a larger electrofishing unit. The lower end of each segment to be measured was blocked with a one-quarter inch mesh net whose bottom was carefully embedded in the cobble substrate and whose top was hung above the stream on concrete reinforcement rods driven into the stream at about 10 foot intervals. The upstream end of each segment sampled was always a very swift riffle where it was not possible to maintain a net. We relied on high current velocities (about 5 fps and above) to prevent significant numbers of fish escaping upstream. Observers at these upper borders were unable to ever see any escaping fishes.

Each collecting pass began at the downstream net. The reach was systematically sampled in an upstream direction to the upper end and then down again to the block net. Catch

from the up and downstream run was lumped together as a single pass sample.

The generator and shocking unit were towed along in a boat from which hung a cable cathode. Fish collection required two individuals with dip nets that were anodes, backed up by two other individuals with dip nets that were anodes, backed up by two other individuals with unwired dip nets. After each pass, the downstream block net was cleaned of both fish and debris. Many of the fish were captured unconscious in the block net.

Following each pass, the collected fish were tranquilized with MS222, counted, and their total lengths measured. Biomass was estimated by measuring the volume of water displaced by a representative number of each species in a 1000 ml beaker and multiplying the mean biomass by the total numbers of that species estimated to be in the population.

Collection was efficient enough so that catches of the more abundant fishes diminished quickly with the three successive passes. We used the data from the diminishing catch to estimate population with the linear regression technique of Hayne (1949). Population estimates of young-of-the-year steelhead, of yearling steelhead and chinook salmon, and sculpins, rarely had R^2 values less than 0.5 and usually above 0.7.

We caught 12 species, 7 of which were common, during our electrofishing program in August. Salmonids constituted 43% of the biomass. The bulk of the remainder were sculpin and dace. The total fish biomass was high, ranging from 155 to 783 kg/hectare. The highest biomass was in pools.

Pools held more fish and more species than riffles. Riffles held fewer species and carried less biomass, while glides were intermediate to pools and riffles (fig. 16).

The following account by species of the fishes in the Tucannon River is based on all of our sampling, other observations, and discussions with local residents and others.

LAMPREYS

Pacific lamprey, Entosphenus tridentatus, ammocoetes were caught in quiet backwater areas that were covered with silt. They were found in the lower zone of the river (Fletcher's) to as far upstream as a pool by the Tucannon Campground (highest reach sampled). They were not caught in great numbers anywhere.

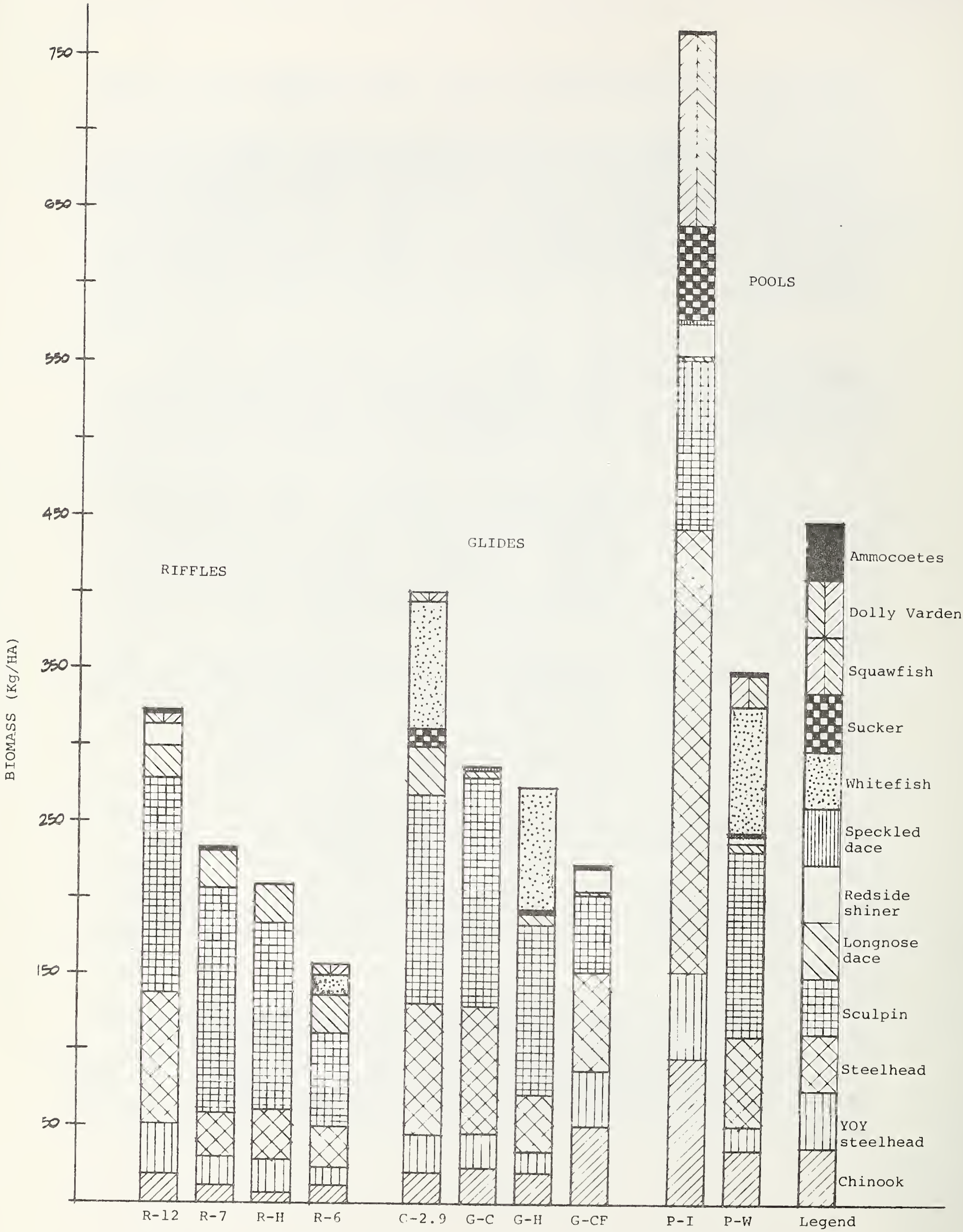


Figure 16. Population of fish in 4 riffles, 4 glides, and 2 pools of the Tucannon River near the Hatchery and Wooten sampling stations.

MOUNTAIN WHITEFISH

Whitefish, Prosopium williamsoni, were caught from Marengo upstream to pool W near Watson Lake. We did not catch enough of them to define preferred habitat.

STEELHEAD

Both steelhead and resident rainbow trout, Salmo gairdneri live in the Tucannon River. We could not distinguish the two and will refer to all S. gairdneri as steelhead. The adult steelhead enter the Tucannon River from October until March, and commence spawning around April 1. The eggs and fry develop in the gravel from early April until early July.

We found young-of-the-year and yearlings abundant in the upstream reaches of the Tucannon River during the summer of 1980--good evidence that large numbers of juveniles remain there for their first two years of life. During July and August, the young-of-the-year steelhead ranging from 32 to 87 mm. total length were abundant in most habitats we sampled down to and including the Marengo Station (fig.17).

Yearling steelhead, ranging from 9 to about 15 cm were abundant downstream to about Bridge 14, in waters a foot or more deep and where current velocities were less than about 3 feet per second (fig. 18).

We caught no yearling steelhead in the Marengo area or below there, however. Late summer water temperatures probably drive the young-of-the-year out of the river below about Bridge 14, and they never return to reach yearling size there.

The size of both young-of-the-year and yearling steelhead from the Tucannon compares favorably with that of similar aged steelhead and rainbow from other streams listed in Carlander (1969).

The Washington Department of Game plants young-of-the-year steelhead in the Tucannon River. A large plant was made near the fish hatchery shortly before we began the electrofishing. We believe that these fish cause the small 75-80 mm. mode in the young-of-the-year length frequency diagram.

Large catchable size rainbow are also planted for anglers, but most are put into a series of ponds along the river. We caught few steelhead larger than yearling size.

We saw few adult steelhead in the Tucannon, although

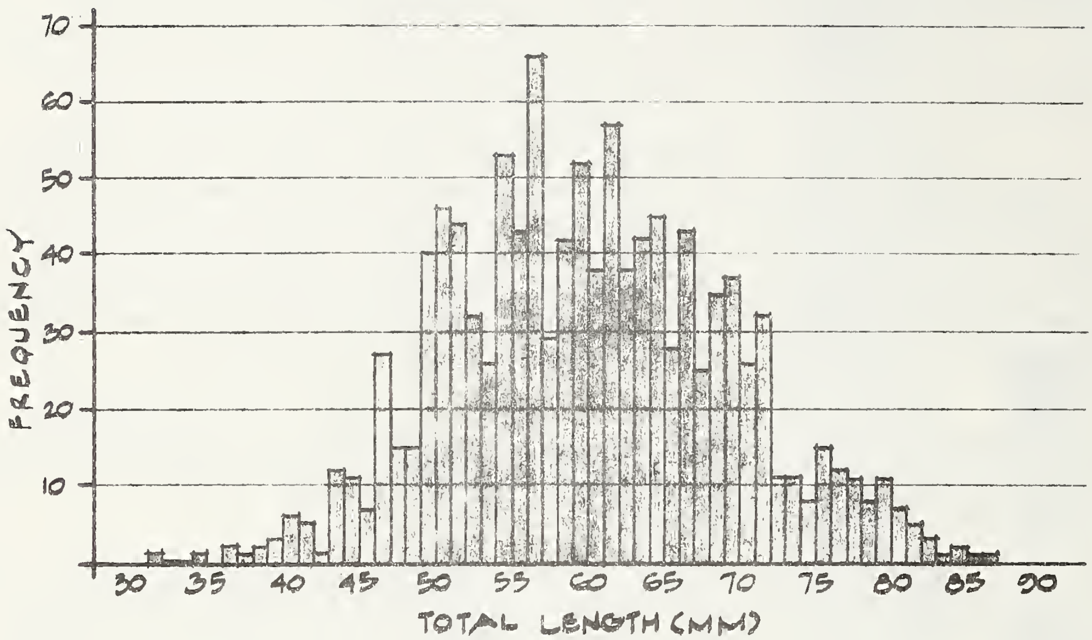


Figure 17. Length frequency of young-of-the-year steelhead from the Tucannon River, July and August, 1980.

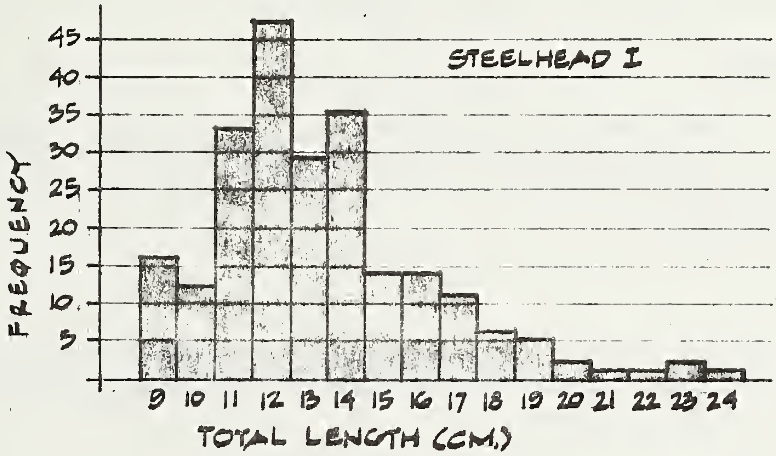


Figure 18. Length frequency of yearlings and older steelhead and rainbow trout collected by electrofishing from the Tucannon River in July-August, 1980. Most were collected near the Hatchery and Camp Wooten sites.

we made no special search for them. Most probably migrate to the upper reaches and tributaries to spawn. We did witness some spawning as far downstream as Krouse's.

Washington Department of Game punch card returns indicate that the annual catch of adult steelhead ranged from less than a hundred to slightly over 700 adults until the fishery was closed in 1974 (table 19).

DOLLY VARDEN

A few small Dolly Varden, Salvelinus malma, were caught near the Hatchery in early June and in the riffles and runs near Watson Lake in late August. They are occasionally taken by anglers.

BROOK TROUT

Brook trout, Salvelinus fontinalis, were planted in 1951 and 1952 by the Tucannon Hatchery. We did not catch any during our study period.

PINK SALMON

Pink salmon, Oncorhynchus gorbuscha, were found by Lyle Gilbreath, NMFS, in the lower Tucannon River near Starbuck in the fall of 1975. It is not clear where these fish came from or whether they spawned (Basham & Gilbreath, 1978).

COHO SALMON

Coho salmon Oncorhynchus kisutch were last seen in the river in 1955 by local residents and WDF&G personnel.

CHINOOK SALMON

The chinook salmon Oncorhynchus tshawytscha we caught were spring run fish. The adults enter the Tucannon River from April until June, migrate to the upper reaches of the river, and spawn in mid-August. Spawning season lasts for two or three weeks and usually peaks in early September. The eggs and fry develop in the gravel from mid-August until mid-February (Simons, 1971). The Game Department found that most young salmon spend only one summer in the Tucannon before migrating to the ocean (Washington Departments of Fisheries and Game, 1961). They smolt from early April to early June in their second spring. We found only a few that might have been in their second summer (fig. 19).

Most spawn upstream from Camp Wooten and we saw only

Table 19. Catch of steelhead on the Tucannon River reported by angler punchcards (Washington Department of Game data).

Dec - March	STEELHEAD Tucannon Punchcard Data	Dec - March	STEELHEAD Tucannon Punchcard Data
1947 - 48	55	1961 - 62	87
1948 - 49	43	1962 - 63	148
1949 - 50	89	1963 - 64	67
1950 - 51	51	1964 - 65	29
1951 - 52	374	1965 - 66	
1952 - 53	442	1966 - 67	
1953 - 54	567	1967 - 68	189
1954 - 55	275	1968 - 69	252
1955 - 56	146	1969 - 70	146
1956 - 57	138	1970 - 71	82
1957 - 58	689	1971 - 72	67
1958 - 59	372	1972 - 73	79
1959 - 60	246	1973 - 74	24
1960 - 61	61		

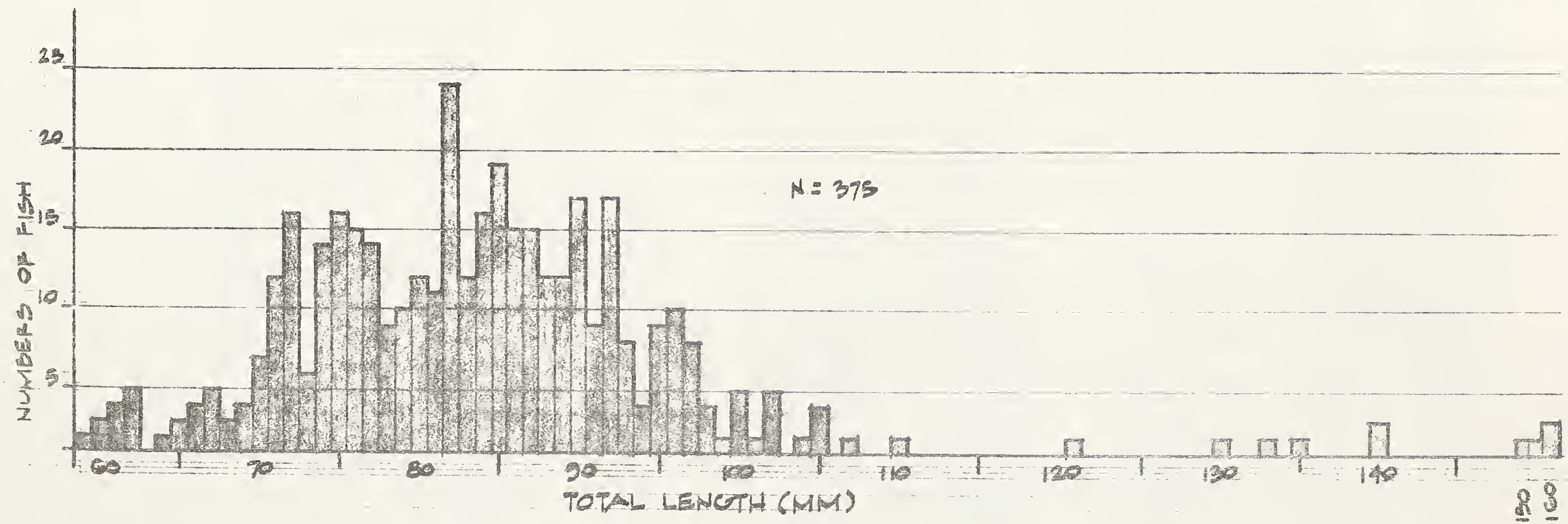


Figure 19. Length frequency of chinook salmon collected by electrofishing in the Tucannon River in 1980. Most were taken in the Hatchery and Camp Wooten areas.

a few adult salmon in the river. The Washington Department of Fisheries has counted salmon nests in a 3-mile reach between Camp Wooten and Panjab Creek each year since 1957. This reach is considered to be the best chinook spawning habitat. The number of nests counted here each year has varied from 6 to 127 (table 20). The Department has also estimated annual angler catch ranging from less than 100 to almost 1000 fish (table 21). Emergency closures of the fishery because of poor upriver runs have resulted in no documented records of catch on the Tucannon since 1974.

The Washington Department of Game has noted that the Tucannon once had a fall run of chinook (Simons, 1971). Department biologists report that this run disappeared prior to 1960 (Washington Departments of Fisheries and Game, 1961). Lyle Gilbreadth, NMFS, found fall run chinook spawning in reaches between the delta and Starbuck in the fall of 1975. We surveyed the river in November and December, 1980 for these fall run fish, but found no salmon. Local citizens reported that salmon had spawned there. We found signs of recent digging in the relatively loose gravel of the very lower end of the river.

CARP

We saw large numbers of adult carp, *Cyprinus carpio*, throughout our fieldwork below the Fletcher diversion dam and in the river downstream to its mouth. The dam apparently prevents their further upstream movement.

CHISELMOUTH

We caught chiselmouth, *Acrocheilus alutaceus*, only below the Fletcher diversion dam. Their upstream movement may also be blocked by that dam.

REDSIDE SHINER

We caught redside shiner, *Richardsonious balteatus*, from Fletcher's Ranch upstream to reaches near Watson Lake. They were never abundant anywhere we sampled.

LONGNOSE DACE

We found the longnose dace, *Rhinichthys cataractae*, to be common in riffles from Fletcher's Ranch upstream to reaches near Watson Lake. They seemed well adapted to the faster water.

SPECKLED DACE

We caught the speckled dace *Rhinichthys osculus* in

Table 20. Number of chinook salmon nests counted in a 3 mile reach of the Tucannon River from Cow Camp to 1 mile below Camp Wooten (Washington Department of Fisheries 1980).

Year	Redd count	Year	Redd count	Year	Redd count	Year	Redd count
1957	127	1963	21	1969	61	1975	37
1958	54	1964	61	1970	62	1976	13
1959	27	1965	24	1971	6	1977	19
1960	42	1966	65	1972	23	1978	--
1961	102	1967	40	1973	24	1979	--
1962	52	1968	18	1974	18	1980	46

Table 21. Tucannon River salmon catch from punch card reports (Washington Department of Fisheries).

Year	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
1964				95	258			2			355
1965				91	268						359
1966				565	389			9	3		966
1967				189	139						328
1968		2		66	52			2	2		124
1969				60	402						462
1970				161	104	4	4	18			301
1971				7	61	5		2		2	77
1972				51	118						169
1973				60	89						160
1974											
1975											
1976											
1977			3								3

riffles and more quiet water everywhere we sampled in the river. They were more abundant in the river from Marengo downstream.

NORTHERN SQUAWFISH

We caught squawfish, *Ptychocheilus oregonensis*, in sheltered areas from Fletcher's Ranch upstream to near Watson Lake. Only a few large fish were caught in the upper reaches. Smaller fish were caught in the lower reaches. They were seen in large numbers between Marengo and Robertson's Bridge, and many were caught at the Marengo Station.

BRIDGELIP SUCKER

We caught a few bridgelip suckers, *Catostomus columbianus*, at Fletcher's and assumed those we caught at most stations upstream were the same species.

LONGNOSE SUCKER

A single specimen of the longnose sucker, *Catostomus catostomus*, was tentatively identified from the Deer Lake side channel.

CHANNEL CATFISH

Local citizens reported channel catfish, *Ictalurus punctatus*, were caught from the Starbuck Bridge pool. We did not catch any during the study period.

SMALLMOUTH BASS

Local citizens reported smallmouth bass, *Micropterus dolomieui*, as far upstream as Starbuck Bridge pool. We seined a few in the Tucannon Delta.

PIUTE SCULPIN
MARGINED SCULPIN

Both Piute sculpin, *Cottus beldingi*, and margined sculpin, *C. marginatus*, were caught in a wide variety of water types from pools and glides to very fast riffles. They were abundant as far downstream as Marengo Station. From the random collection of specimens, it appears that the Piute sculpin outnumbers the margined sculpin.

CHAPTER VII. SALMONID REARING HABITAT

METHOD

During the summer of 1980, we measured the quantity and quality of habitat suitable for the rearing of juvenile salmonids in the Tucannon River from Sheep Creek to its mouth. Dr. Li measured and graded each riffle, glide, and pool in the 18 representative reaches as either zero, poor, fair, good, or excellent juvenile salmonid habitat. The grade assigned each pool, riffle, and glide was based on Dr. Li's opinion of how the variables of current velocity, substrate, depth, instream cover, and shade, combined to provide rearing habitat for juvenile salmonids.

Working alone or with one field assistant, he rated the 19.6 miles of the Tucannon River in 21 days when the stream was low and clear during August and September. He rated and measured 84 pools, 233 glides, 677 riffles, and 52 other segments that did not fit these categories. Some of the ratings were adjusted after the electrofishing data was analyzed and we understood more about how high current velocity seems to limit young salmonid use of some habitat.

Since the habitat rating was to be calibrated by comparison with actual measurements of fish populations, any consistent numerical system of rating could have been used. We have found it easier to make consistent decisions in the field, day after day, if we adopt a geometrical progression of--poor = 1, fair = 2, good = 4, and excellent = 8. The biologist must then only have a clear understanding of what is "excellent" habitat and then rate the area he is currently viewing in one of these four categories that are well separated from each other.

JUVENILE SALMONID HABITAT QUALITY

Pools on the Tucannon River were relatively easy to grade. They were usually deeper than 24 inches, so lack of depth was not a constraint to higher ratings. Pools were usually small and streamflows high enough so that lack of current needed to carry drifting food well into the pool was not a constraint. Small gravel embedding cobble and boulders in some pools reduced habitat quality. Those with undercut banks or a surface riffle tended to be rated higher, because these features provided additional cover for fish. The presence of eddy currents also enhanced the quality of some pools

because they provided additional opportunities for the salmonids to capture drifting organisms.

Glides were more difficult to rate than pools. An important factor was water depth. If the water was less than 12 inches in glides, Dr. Li generally lowered the quality rating. Substrate size was an extremely important criteria in glides, with larger rocks providing more shelter from the stream's current and from predators. Velocity was the principal constraint to habitat quality in glides, but a glide with a high stream velocity of 2 or 3 feet per second, was rated higher if the substrate consisted of large rocks or cobble and was less embedded in sand. Additional factors such as undercut banks and surface riffles tended to increase the rating of glides even if they were less than 12 inches deep.

Riffles were the most diverse of all stream segments and the most difficult to rate. They were generally the stream segments with the highest stream current. Current velocity above 4 feet per second over part of the riffle was always the principal constraint to higher habitat quality ratings. Features which compensated for this fast current--additional depth, a large boulder or cluster of boulders, a rough cobble and boulder substrate behind which salmonids could take shelter, tended to increase the rating.

Pools were consistently rated of higher quality than glides, and glides higher than riffles, which were often constrained by too high current velocities (table 22). Glides in the upper reaches were often rated higher than glides in the mid- and lower reaches, because the large cobble and boulders more prevalent in the upper reaches provide more shelter from high velocities.

Overall - habitat quality throughout the reach is surprisingly similar, averaging, on our scale of 1-8, 3.01 in the upper river; 2.56 in the middle river; and 2.93 in the lower river.

REARING INDEX

These habitat quality ratings and the measurements of width and length from each pool, riffle, and glide were converted into "rearing indexes" - an expression of the quality of rearing habitat <u>per</u> <u>lineal</u> <u>foot</u> of stream.

$$RI = \frac{\text{rating x area rated}}{\text{length of stream rated}}$$

Table 22. Juvenile salmonid physical habitat quality ratings./1

LOCATION	POOLS n-mean	GLIDES n-mean	RIFFLES n-mean	OTHER CHANNELS n-mean	Overall Mean
Sheep Creek	5-6.40	7-6.29	32-2.34	3-5.33	3.31
L. Tucannon	5-6.40	10-4.90	26-2.15	3-1.67	3.04
Ranger	1-8.00	9-6.00	35-2.70	5-2.20	3.89
Watson Lake	5-8.00	4-4.00	22-2.23	5-0.50	2.66
Hatchery	0-0	13-4.35	45-2.64	5-0.80	2.72
Cummins Creek	3-5.33	14-4.77	35-2.70	1-0.50	2.76
Bridge 14	0-0	4-5.00	42-2.69	0-0	2.66
UPPER RIVER	19-6.74	60-5.03	237-2.53	19-1.97	3.01
Bridge 10	3-8.00	24-3.65	45-2.49	3-0.50	2.24
Bridge 9	9-4.67	28-3.46	45-2.08	7-2.07	2.53
Marengo	3-5.33	10-3.40	39-2.26	4-4.40	2.69
King Grade	13-5.85	14-4.00	55-2.22	4-3.38	3.02
Robertson	5-7.20	13-4.00	34-2.18	3-0.50	2.35
Frame	8-6.50	17-3.41	38-1.96	4-1.75	2.54
MIDDLE RIVER	41-6.00	106-3.63	256-2.21	25-2.22	2.56
Krouse	10-6.00	15-4.27	68-2.53	3-0.50	3.12
Smith Hollow	4-6.00	15-3.27	31-2.18	2-0.50	2.98
Fletcher	2-8.00	14-5.00	40-2.50	1-0.50	2.97
Starbuck	8-6.00	14-4.29	32-1.72	1-2.00	2.87
Powers	5-6.40	9-3.42	13-2.08	1-0.50	2.69
LOWER RIVER	29-6.21	67-4.09	184-2.29	8-0.69	2.93
TOTAL	84-6.23	233-4.12	677-2.34	52-1.89	2.79

/1 Each pool, riffle, and glide was rated as poor (1), fair (2), good (4), or excellent (8). All ratings in a segment were summed and averaged.

We tested the validity of Dr. Li's habitat assessments and calibrated the resulting rearing indexes by measuring the fish populations in two pools, four glides, and four riffles which he has assessed. The estimated fish populations in each was converted to numbers of yearling steelhead, young-of-the-year chinook salmon, and young-of-the-year steelhead, per lineal foot of each of the ten sites.

Two assumptions are required to make such tests valid. We must assume that the stream was fully seeded so that competition for suitable physical habitat will occur and the resulting population of juvenile fish will depend upon the quality and quantity of that habitat - not on the number of eggs that had been previously deposited or hatched. The second is that no other factor such as water temperature or water quality will, in the different reaches being used for calibration, have had a different effect on the survival from the time full seeding occurs, to the time the population was measured.

Our observation of good water quality, low temperature, and abundant young-of-the-year led us to believe that both assumptions were valid in the upper reaches where the population estimates were made.

For both yearling steelhead and juvenile chinook salmon, we found a high linear correlation between the number of fish per lineal foot of stream, and the rearing index developed for each of the ten sites where population data was available (fig. 20). The high correlations are evidence that Dr. Li's assessment and Rearing Indexes were valid.

Lines of best fit were calculated with statistical regression techniques and formulas developed for converting the rearing indexes to numbers of yearling steelhead and chinook salmon per lineal foot of stream.

$$\text{yearling steelhead} = 0.07 + 0.008\ \text{RI}$$

$$\text{Young-of-the-year chinook} = 0.01 + 0.014\ \text{RI}$$

The high correspondence of Rearing Index to density of young-of-the-year steelhead was fortuitous (fig. 21). Young-of-the-year steelhead were caught along the margins of all reaches. Consequently, the fish population density estimates tended to be clumped around 2.5 fish per foot in reaches that were very different. We do not believe our Rearing Indexes are useful in calculating the young-of-the-year steelhead populations on the Tucannon River.

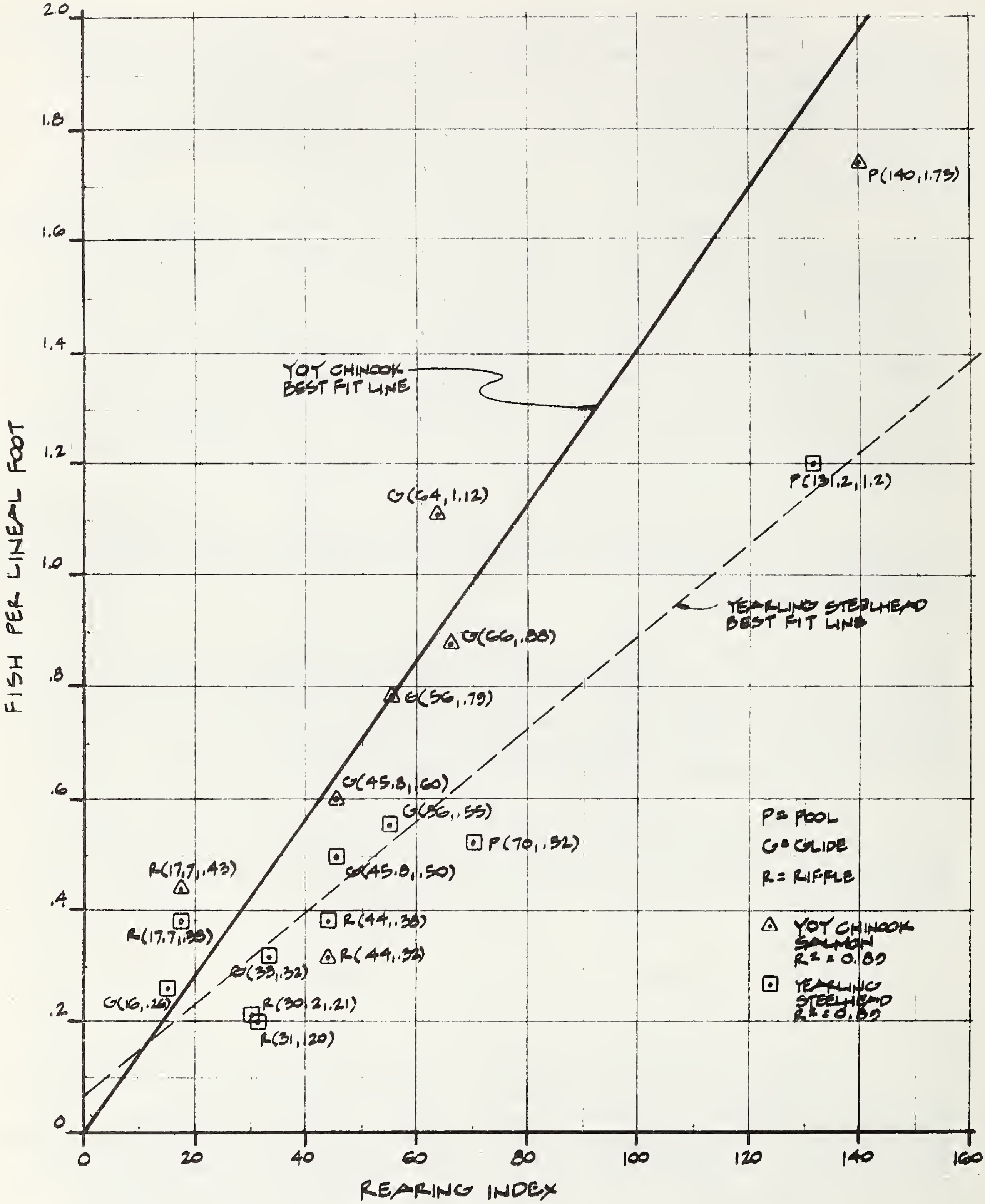


Figure 20. Relationship between the rearing indexes and the number of yearling steelhead and juvenile chinook salmon per lineal foot in 2 pools, 4 glides, and 4 riffles of the Tucannon River.

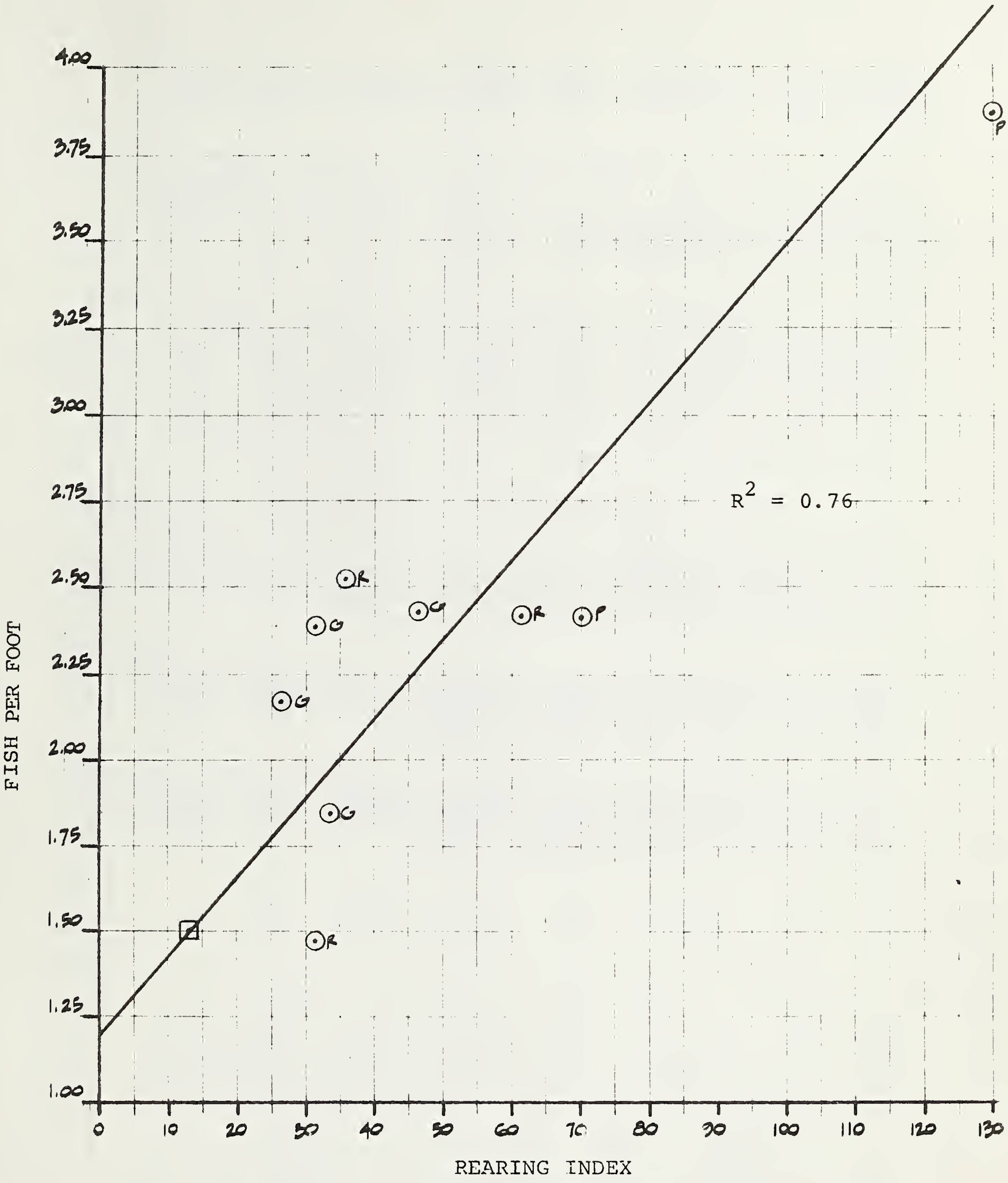


Figure 21. Relationship between the Rearing Indexes and the number of young-of-the-year steelhead per lineal foot in 2 pools (P), 4 glides (G), and 3 riffles (R) of the Tucannon River.

ESTIMATE OF POTENTIAL SALMON AND STEELHEAD PRODUCTION

With the formulas converting Rearing Index to the numbers of fish per foot of stream we estimated the capacity of each small river section to rear yearling chinooks and steelhead by multiplying its length by the mean Rearing Index of that reach (table 23).

One correction on estimated length of each section was needed because the channel of the Tucannon River is, in places, braided into several subchannels by extensive deposits of cobble and gravel. The USGS estimate that the Tucannon River from the confluence of Bear Creek to its mouth is 53.4 miles long does not include this braiding, which according to Dr. Li's measurements would add 15% to the upper reach, 18% to the middle reach, and 12% to the lower reach (table 24).

With this information, we estimate that the physical habitat in the Tucannon River from Sheep Creek to its mouth would, if water temperatures are not too warm and if the entire stream was fully seeded, rear about 280,000 steelhead to yearling size and about 430,000 chinook salmon to at least the middle of the first summer (table 25).

The potential is, of course, not realized. The actual populations in the Tucannon River during the summer of 1980 were near 111,000 steelhead yearling and 170,000 chinook - about 40% of that potential.

The principal constraint to realizing that potential is water temperature in the middle reaches and a combination of high water temperature and, probably, a lack of suitable spawning habitat below Pataha Creek.

Table 23. Estimated potential numbers of yearling steelhead and young-of-the-year chinook salmon that could be reared in the main Tucannon River with 1980 stream morphology.

Reach of Estimate	Reach Sampled	RI	Salmon feet	Steelhead feet	River Miles	Braiding Factor	Reach Length	calculated Salmon Pop.	calculated Steelhead Pop.
Bear Cr. to Panjab Cr.	Sheep-Creek	69.58	.9831	.6582	7.8	1.23	50,656	49,800	33,342
Panjab-WootenBr	L.Tucannon	84.56	1.2232	.7955	3.2	1.19	20,106	24,594	15,995
WootenBr-HatcheryBr					6.7				
	Ranger	99.61	1.4645	.9335	2.233	1.16	13,676	20,030	12,767
	Watson	68.37	.9637	.6471	2.233	1.20	14,148	13,635	9,155
	Hatchery	66.09	.9271	.6262	2.233	1.48	17,449	16,177	10,927
HatcheryBr-Tumalum	Cummins Cr	96.79	1.4192	.9076	3.2	1.04	17,571	24,938	15,948
Tumalum-Br.13	Bridge 14	110.33	1.6362	1.0318	2.3	1.02	12,386	20,267	12,781
Br.13-Br.10	Bridge 10	74.94	1.0690	.7073	3.5	1.31	24,208	25,879	17,123
Br.10-Marengo	Bridge 9	61.31	.8505	.5824	2.1	1.33	14,747	12,542	8,589
Marengo-King Grade					3.8				
	Marengo	75.65	1.0804	.7138	1.9	1.20	12,038	13,006	8,593
	King Grade	84.78	1.2267	.7975	1.9	1.16	11,637	14,275	9,281
King Grade-Hwy 12					7.3				
	King Grade	84.78	1.2267	.7975	2.433	1.16	14,901	18,280	11,884
	Robertson	91.65	1.3368	.8605	2.433	1.19	15,287	20,436	13,154
	Frame	75.13	1.0720	.7901	2.433	1.12	14,387	15,424	11,368
Hwy 12-PatahaCr	Krouse	102.61	1.5126	.9610	2.5	1.20	15,840	23,960	15,222
PatahaCr-KelloggCk					6.7				
	Smith Holl.	106.51	1.5750	.9967	3.35	1.22	21,579	33,987	21,508
	Fletcher	142.78	2.1564	1.3293	3.35	1.03	18,218	39,287	24,218
KelloggCr-Powers Road	Starbuck	108.00	1.5989	1.0104	2.2	1.25	14,520	23,216	14,671
Powers-Mouth	Powers	106.56	1.5758	.9972	2.3	1.03	12,508	19,711	12,473
TOTAL								429,524	278,999

Table 24. Measured lengths of the Tucannon River channel including and excluding "braiding".

LOCATION	Miles from mouth	Reach length measured (feet)	River length without braids (feet)	Reach length to river length	River length to reach length
Sheep Creek	48.0	2,965.7	2,402.7	.81	1.23
L. Tucannon	44.0	3,676.5	3,083.5	.84	1.19
Ranger Station	41.8	4,189.0	3,597.0	.86	1.16
Watson Lake	39.8	3,957.9	3,308.2	.84	1.20
Hatchery	34.1	8,033.4	5,433.9	.68	1.48
Cummins Creek	31.7	6,014.5	5,809.5	.97	1.04
Bridge 14	30.2	5,492.5	5,375.5	.98	1.02
UPPER RIVER TOTALS		34, 329.5	29,010.3	.85	1.18
Bridge 10	27.5	8,497.2	6,502.2	.77	1.31
Bridge 9	26.6	6,230.7	4,701.7	.75	1.33
Marengo	25.5	4,564.0	3,814.0	.84	1.20
King Grade	21.8	5,669.8	4,895.2	.86	1.16
Robertson's	18.2	5,761.5	4,822.5	.84	1.19
Frame's	16.5	5,592.5	4,977.5	.89	1.12
MIDDLE RIVER TOTALS		36,315.7	29,713.1	.82	1.22
Krouse's	12.0	9,290.9	7,771.9	.84	1.20
Smith Hollow	8.0	5,431.0	4,441.0	.82	1.22
H. Fletcher's	5.5	6,896.5	6,718.5	.97	1.03
Starbuck	4.0	5,858.0	4,700.0	.80	1.25
Powers Road	2.0	5,456.0	5,306.0	.97	1.03
LOWER RIVER TOTALS		32,932.4	28,937.4	.88	1.14
RIVER TOTALS		103,577.6	87,660.8	.85	1.18

Table 25. Potential annual production of salmon young-of-the-year and yearling steelhead in the Tucannon River (in thousands).

	Miles	Salmon	Steelhead
Sheep Creek to Bridge 13	8.32	170	111
Bridge 13 to Pataha Cr.	9.67	144	95
Pataha Creek to Mouth	4.53	116	73
	22.52	430	279

CHAPTER VIII. STREAM TEMPERATURE MODEL

We have completed a stream temperature analysis of the Tucannon River for August, usually the warmest month, using a longitudinal water temperature model developed by Fred Theurer of the US Soil Conservation Service and the US Fish & Wildlife Service Cooperative Instream Flow Group of Ft. Collins, Colorado.

The model is one dimensional (stream length), and is formed by two components: a heat flux equation, which describes heat exchange at any point in the river, and a hydraulic transport equation which describes the movement of water. The model assumes one dimensional steady flow with complete vertical and transverse mixing, and no longitudinal dispersion.

There are eight components of heat flux in this model. They are: atmospheric radiation (heat), solar radiation (light), vegetative radiation, back radiation from water, evaporation, conduction, friction, and convection. Since all components are measured in joules/m²/sec., their relative contributions to stream temperatures can be measured. The model presents their contributions at a standardized condition - equilibrium temperature, which is the temperature the stream would arrive at under a stable set of conditions given an infinite amount of time. At equilibrium conditions the net heat flux is zero.

We modeled stream temperatures at 13 reaches from the Little Tucannon River to the Snake River. Atmospheric and solar radiation were the most important contributors of heat gain into the stream. Radiation from streamside vegetation and friction added only a little heat. Back radiation and evaporation were the most important heat losses from the stream. Conduction and convection were minor factors in heat loss (fig. 22).

Mr. Theurer calibrated the model using August 1980 thermograph data from the Tucannon River near the fish hatchery. The climatic data used were the average August values recorded by weather stations at Walla Walla and Lewiston. The stream geometry and hydrology data were collected during this Tucannon River study (table 26). Mr. Theurer believes the model is presently operating at less than one degree Celsius error, perhaps as low as one-half degree error. The model's data was similar to our maximum/minimum thermometer measurements taken in August 1980 (table 27). The average daily maximum temperatures measured and calculated with the

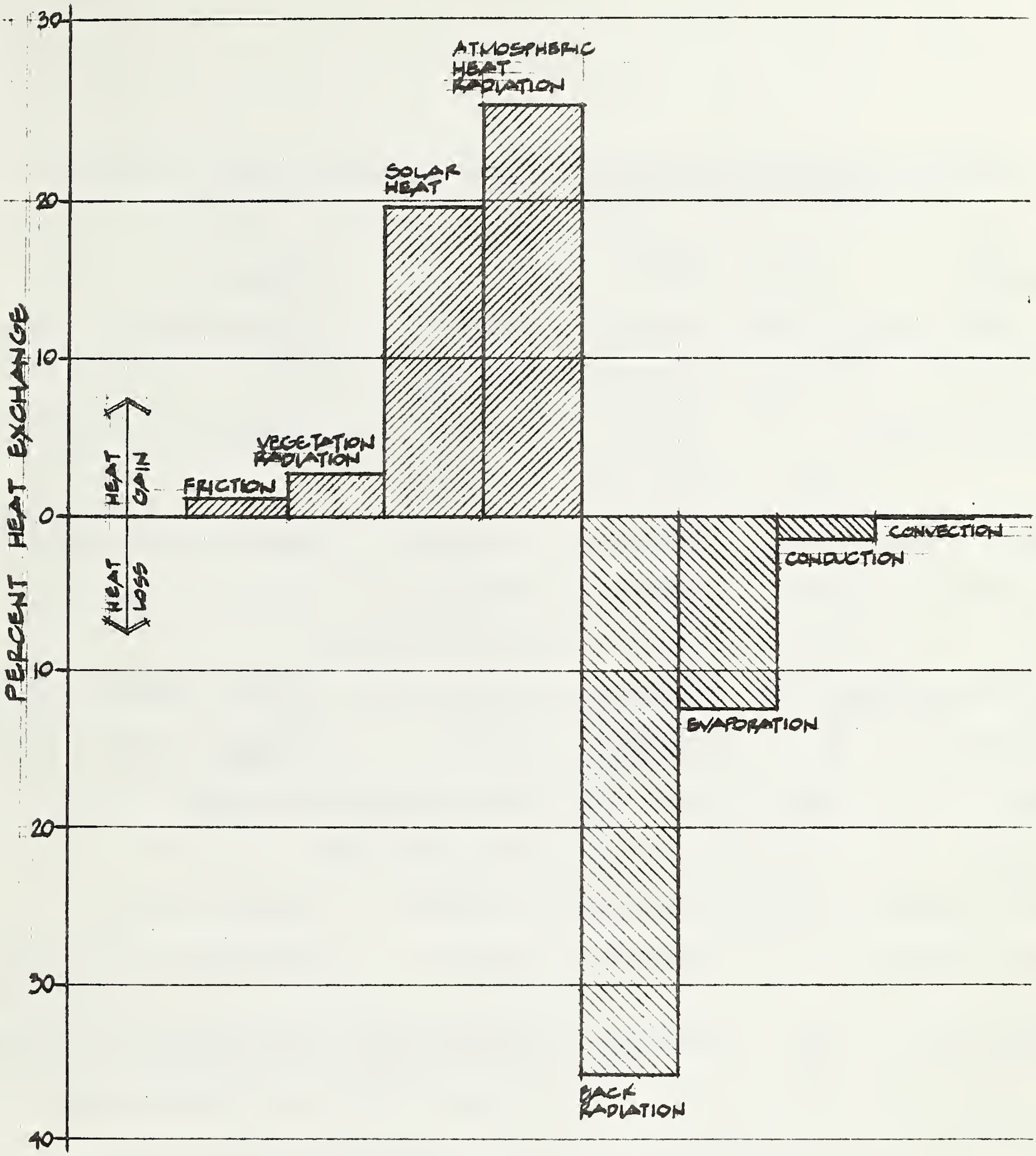


Figure 22. Average contribution of heat flux components at equilibrium temperatures for 13 reaches of the Tucannon River for average August conditions.

Table 26. Data and its sources used in the Tucannon Stream temperature model.

INPUT DATA	UNITS	SOURCE	REMARKS
Solar radiation	j/m²/s	Lewiston, ID USDOE	corrected for elevation
Cloud cover	decimal	Walla Walla, WA NOAA	
Air temperature	°C.	Lewiston, ID USDOE	corrected for elevation
Wind	M/S	Walla Walla, WA NOAA	
Relative humidity	decim.	Walla Walla, WA NOAA	corrected for elevation
Air pressure	mb	Starbuck, WA WA Dept.Ecol.	"
Shade	decim.	Habitat survey, DWK&Assoc.	
Ground temperature	°C.	Tucannon Hatchery WA DG	Est.mean annual air temp.
Ground depth	M	Pluhowski (1970)*	streambed/stream interaction
Gradient	M/M	Tucannon R. USSCS/River mile index	
Discharge	CMS/M	Tucannon R. USSCS/HEA/DWK	
Lateral discharge	CMS/M/KM	Tucannon R. Theurer	Estimate from Q_o
Initial temperature	°C.	Tucannon R. Theurer	Calibrated to Hatchery thermograph
Distance travel	KM	Tucannon R. USSCS/River mile index	Source distance calibrated to Hatchery thermograph

/1 Pluhowski, Edward J. 1970. Urbanization and its effect on the temperature of the streams on Long Island, New York. USGS Professional Paper 627-D. 1970.

Table 27. August water temperatures measured with maximum/minimum thermometers and calculated with Theurer's model. Tucannon River, 1980.

LOCATION	SOURCE	DAILY AVE	DAILY MAX	RANGE (± DAILY AVE)	n
Bridge 12	model	16.90	21.45	±4.5	-
	field	17.07	21.40	±4.33	10
Bridge 9	model	17.90	22.45	±4.6	-
	field	18.17	22.50	±4.33	7
Marengo	model	18.00	22.60	±4.6	-
	field	16.50	21.00	±4.5	1
King Grade	model	18.30	22.50	±4.2	-
	field	17.87	22.67	±4.83	3

model were always less than 1° C. different.

Mr. Theurer has calculated the monthly mean of the daily average and daily maximum stream temperatures using August climate data and existing shade conditions for the 13 reaches along the Tucannon River (fig.23). Daily average temperatures represent the average 24 hour value for the month. Daily maximum temperatures represent the average of daily high values. The daily maximum temperatures exceed 21° C. between Bridge 14 and Bridge 12. These average August stream temperatures are lower than annual maximum temperatures because average August conditions include time in late August when the river is cooling. The peak air temperatures at the USFS Guard Station occurred in the last week in July and the first two weeks in August during 1977-1980 (fig. 24).

Thermal Zones

The distances the water travels in six hours as it warms from the average daily temperature to the daily maximum are represented by dashed lines in figure 23. These thermal zones of influence are longer in the upper reaches of the river because the gradient there is steeper and the water travels faster and farther in six hours.

Modeling Existing Conditions

The daily average, the daily maximum, and the equilibrium temperatures increase in the downstream direction, reflecting the net accumulation of heat gained upstream and greater warming effect of air temperature, relative humidity, and air pressure as the river drops in elevation.

Effect of Water Temperatures on Fish

The lower zones of the river have daily average temperatures close to 21° C. and periods that exceed this temperature for most of many days. The modeling confirms our observations that Tucannon stream temperatures during August are high enough to stress steelhead and chinook salmon daily as far upstream as Bridge 12 (River Mile 29.4) when young-of-the-year are growing.

We believe these high stream temperatures sufficiently stressed young-of-the-year steelhead and chinook salmon to reduce their population densities in the reaches downstream from the hatchery as temperatures rose during August. We caught few young-of-the-year steelhead, no yearlings, and no salmon below Marengo in August.

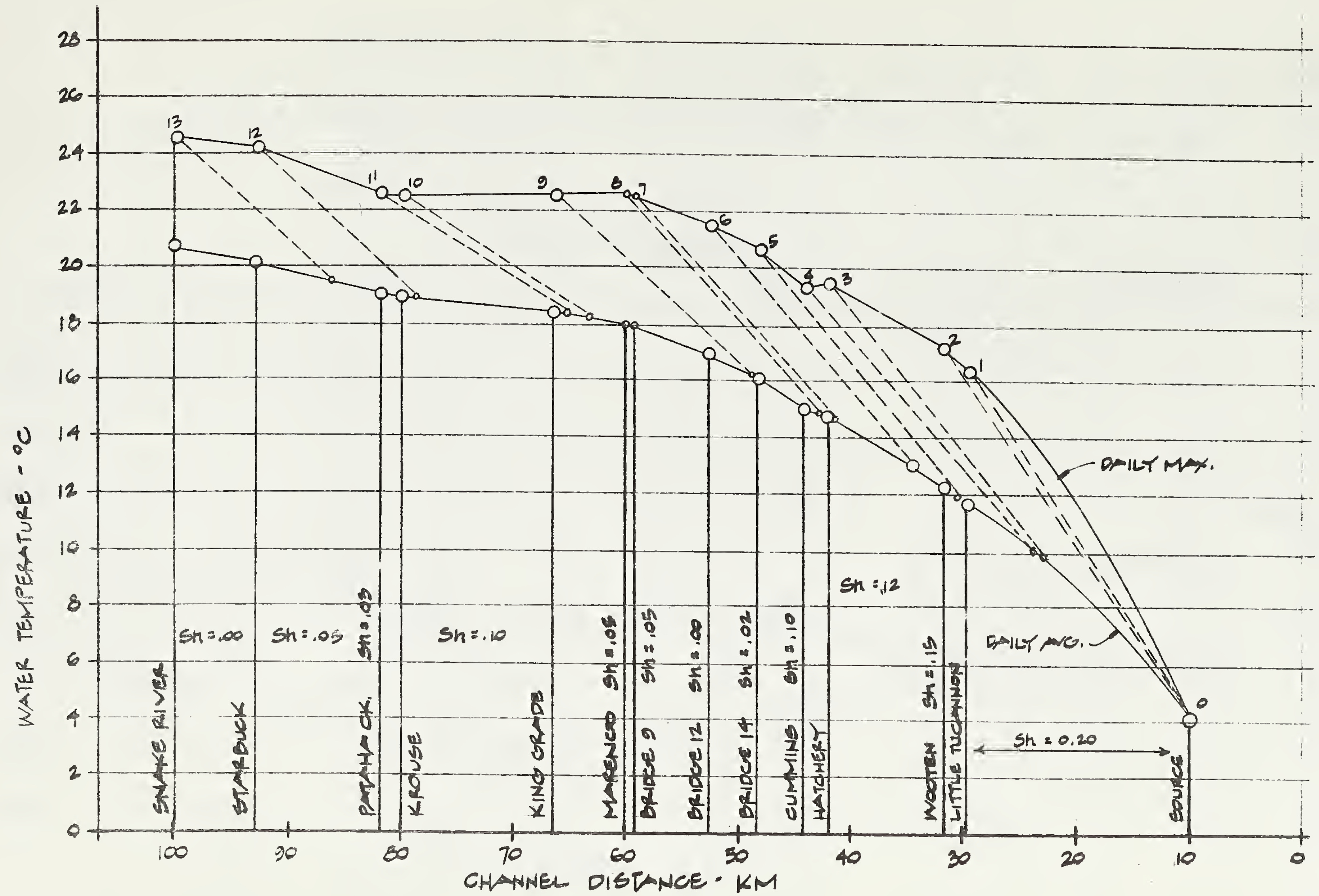


Figure 23. A profile of daily average and daily maximum stream temperatures calculated for 13 reaches of the Tucannon River under average August conditions. Dashed line indicates thermal zone of influence for 6 hours.

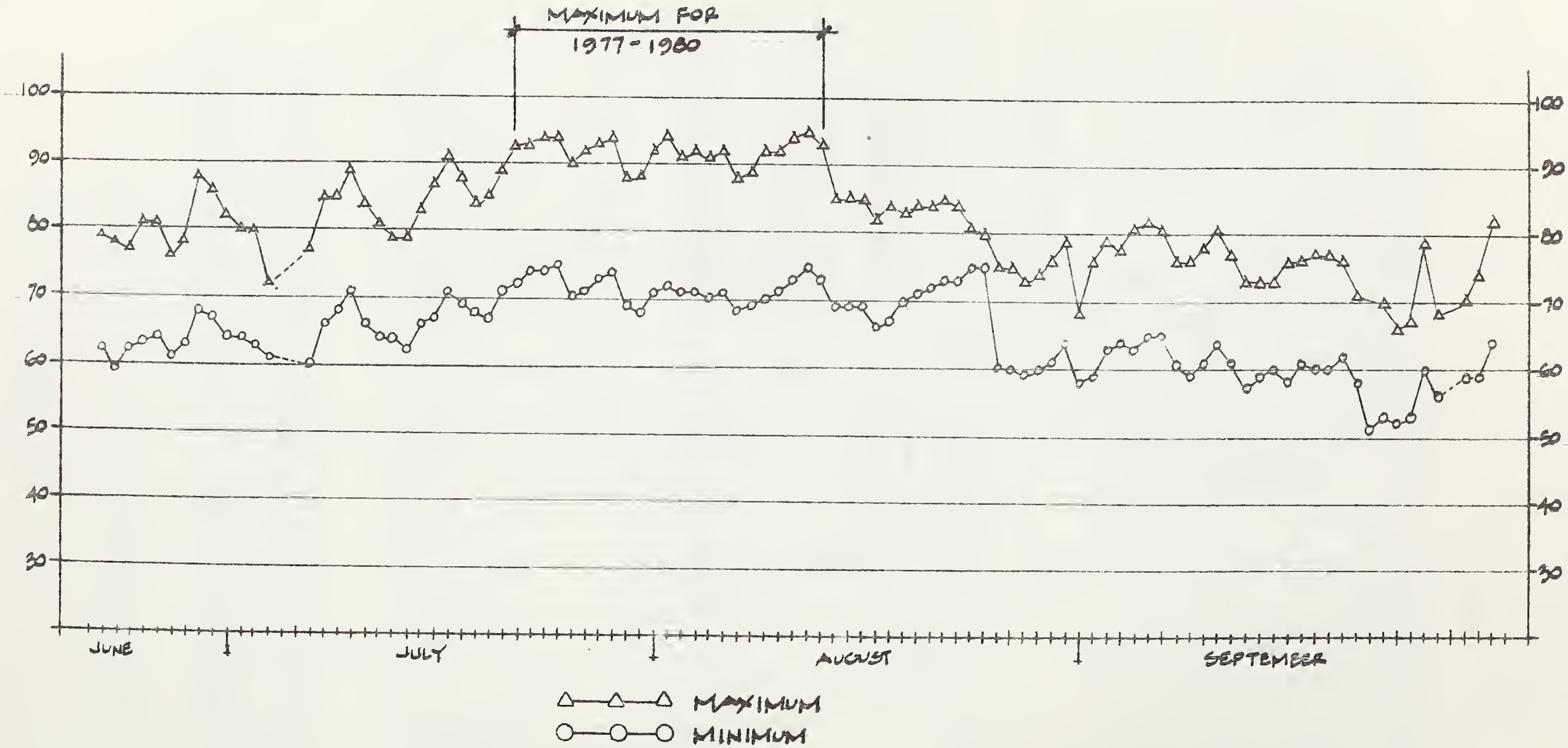


Figure 24. Tucannon Guard Station air temperatures showing annual peak air temperatures in late July and early August.

Yearling steelhead were also scarce in these middle to lower reaches. We did not catch any yearlings below the hatchery, despite the good quality of the physical habitat.

The high stream temperatures may also impede some returning adults. S. Li found a recently dead female chinook salmon adult still carrying developing eggs near Elmer DeRue's in late July when stream temperatures were too high.

Modeling the Tucannon River with Improved Shade Conditions

When we made our habitat survey, we noted that there were many parts of the river, particularly in the middle and lower zones of the river, that lacked streamside vegetation and were therefore fully exposed to the sun. We modeled the Tucannon River with our estimate of existing shade conditions and with various levels of improved shade conditions to see how stream temperatures might be reduced if more shade was provided.

Shade is a very difficult variable to quantify (Quigley, 1981). S. Li estimated the percentage of morning and afternoon shade for the reaches measured in the habitat survey. We used these estimates for the existing shade conditions on the river. Mr. Theurer estimates an error of .09° C. for every percent inaccuracy. We modeled improved shade conditions in 10 percent increments from 10 to 60 percent shade. Only those reaches with less than the minimum percentage of shade were given additional shade.

In general, the model predicts a daily maximum temperature decrease of 0.8° C. (fig. 25), and a daily average stream temperature decrease of 0.4° C. (fig. 26) with each 10% increase in shade. Since equilibrium temperatures increase in the downstream direction due to the increased warming influence of air temperature, air pressure, and relative humidity as the river drops in elevation, the most effective management of shade to reduce water temperature must begin at the upstream end and proceed continuously downstream. Because of the fast flows, once the stream temperatures go up they will not come down (Theurer, 1981).

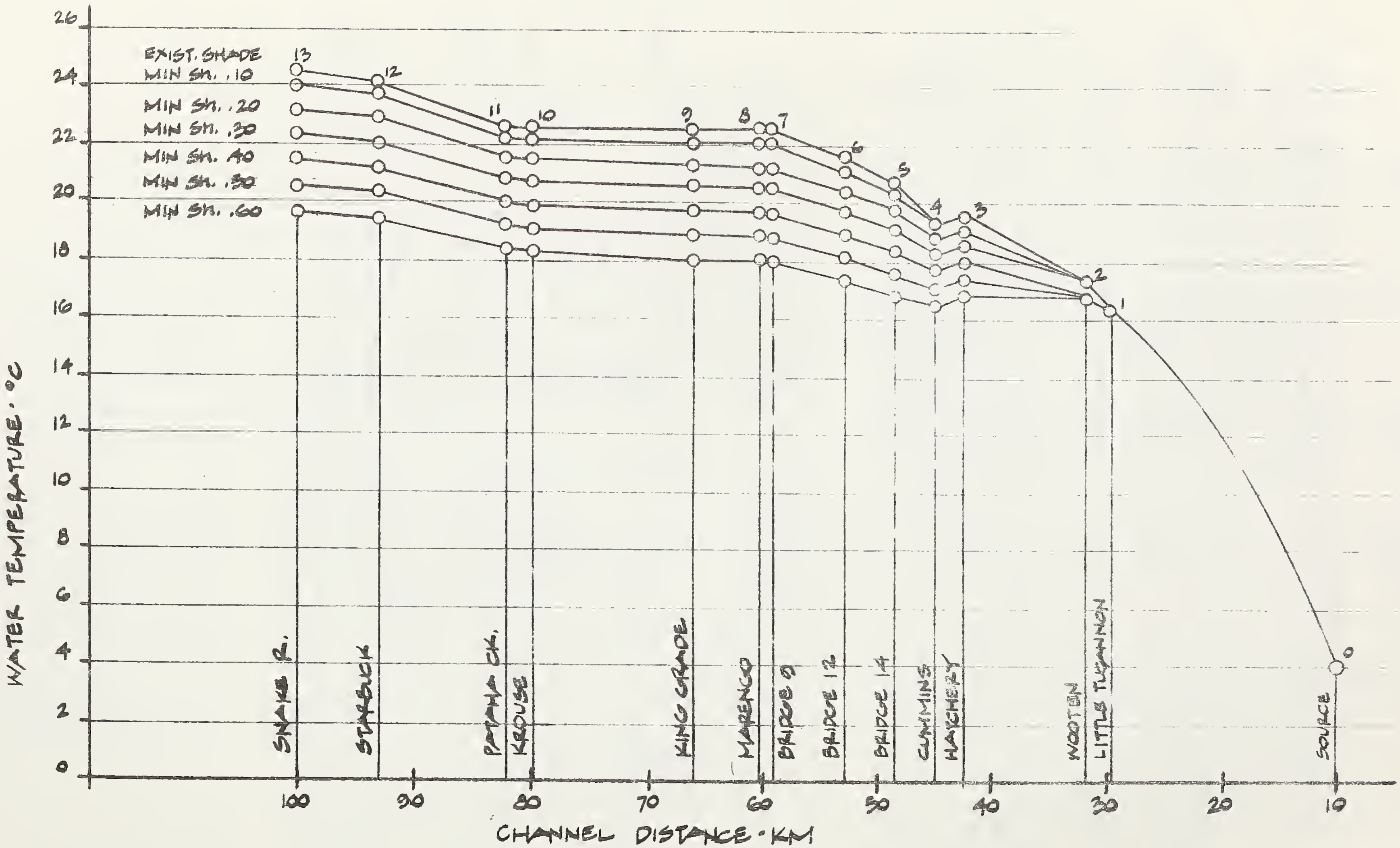


Figure 25. Profile of Tucannon River daily maximum stream temperatures with existing and improved shading in an average August.

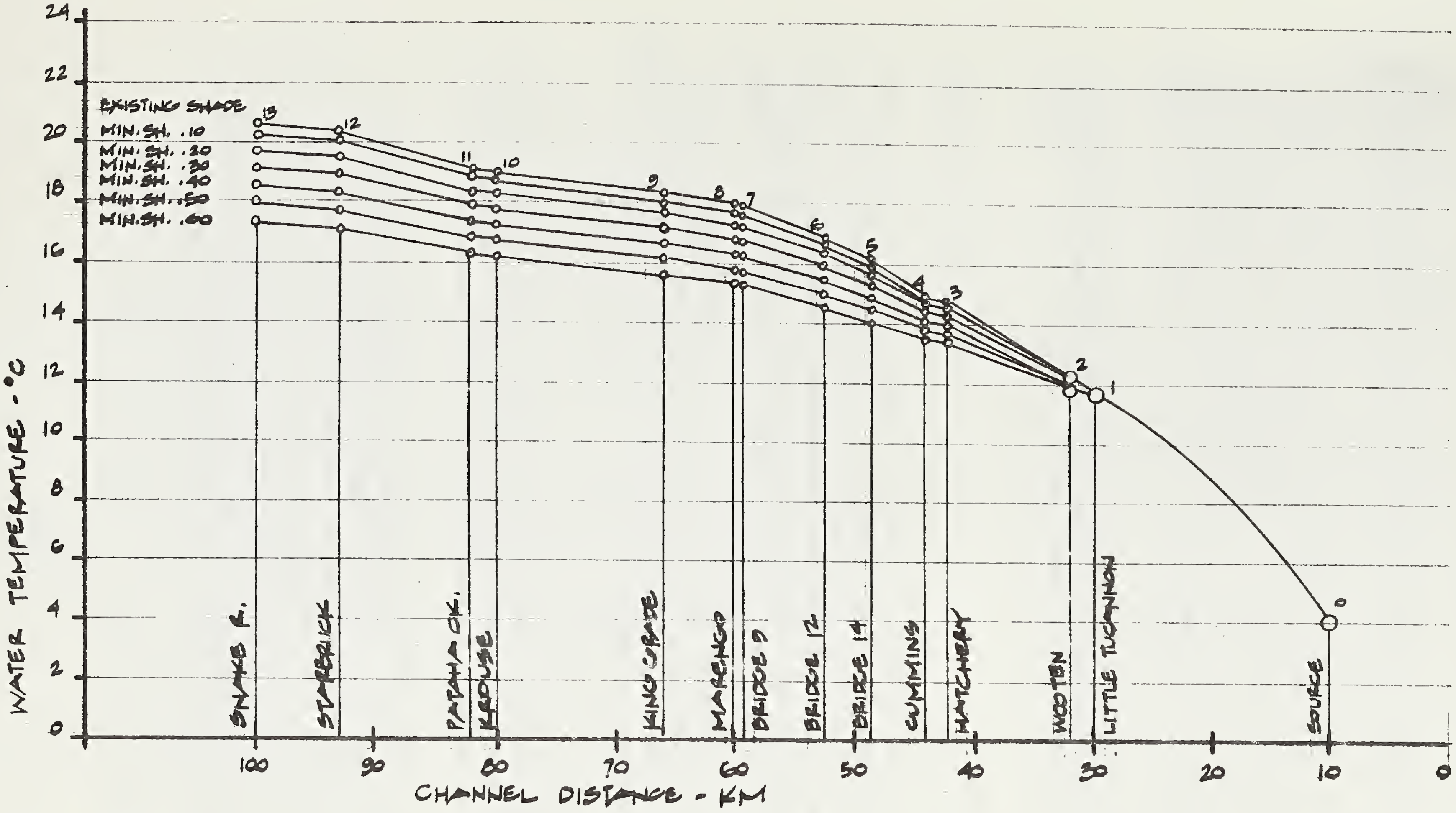


Figure 26. Profile of Tucannon River daily average stream temperatures with existing and improved shading in an average August.

CHAPTER IX. PRESENT CONSTRAINTS TO SALMONID PRODUCTION

Our investigations have led us to conclude that the production of salmon and steelhead and other salmonids in the Tucannon River is presently constrained by high velocities in the upper reach, by high water temperatures in the middle reaches, and by high temperatures, mobile substrate, and deposition of fine sediment in the lower reaches. Were it possible to eliminate these constraints with a management plan for the river corridor, we estimate that approximately 260,000 additional steelhead and 168,000 additional steelhead yearlings could be produced.

The following paragraphs describe the individual constraints, how they are related, and the potential for improvement if they can be modified.

WATER TEMPERATURE

Our measurements of water temperature and analysis of data gathered by others, leads us to believe that the Tucannon River below about Bridge 12 (River Mile 29.4) becomes too warm by early or mid-August to support large numbers of salmonids. Those that live below there must live in deep holes or beneath undercut banks of which there are very few.

The principal reason for high summer water temperatures is the lack of shade. The very high flood flows of 1964-65 are reported to have washed away most of the old stands of large cottonwoods along the river that provided shade (Dwayne Scott, USSCS, Dayton, personal communication). Subsequent floods of 1968-69 and 1973-74, and channelization of the river that followed have prevented recovery. Restoration of that shade and reduction of water temperature should be the highest priority for those concerned with habitat improvement for salmon and steelhead on the Tucannon River.

Below about Bridge 14 (River Mile 32), water temperatures in March or April also become too high for successful incubation of <u>late</u> hatching steelhead or rainbow trout eggs that remain in the river gravel. Because the summer temperature is too high to rear the young below there, this is not a serious problem now. If spring and summer water temperatures could be reduced by restoring adequate shade along the middle and lower Tucannon, <u>late</u> spring spawning of steelhead and/or rainbow would become more important. We mention this because the fish

that spawn late in the season have a better chance of surviving the dangers of sedimentation and scour than those whose eggs are buried throughout the winter. Full seeding of the entire river would then become more likely.

We estimate that if water temperatures in the Tucannon River only down to Pataha Creek could be reduced to levels suitable for salmonids, an additional 95,000 yearling steelhead and 144,000 chinook salmon would be reared there. This would nearly double the present production of the river. Such estimates require the assumption, of course, that sufficient adults would be available to seed this reach of the stream. If the temperatures from Pataha Creek downstream to the mouth could be reduced to satisfactory levels, an additional 73,000 steelhead and 116,000 chinook could be reared - once again assuming that the reach could be well seeded.

SUBSTRATE CONDITIONS

The common problem of sand or fine gravel filling the living spaces for juvenile salmonids around and under cobble and boulder is of minimal significance on the Tucannon River. The degree of cobble embeddedness increases rapidly from a pristine 10-15% near Camp Wooten, to 30% at Bridge 13 some 13 miles below, and below which the summer water temperatures are too warm for juvenile salmonid rearing (fig 5). Below there, the degree of embeddedness increases slowly, only to about 35% toward the river's lower end.

The concept that damage to salmonid rearing habitat might be measured by the degree cobble was "embedded" in sand was developed by Bjornn and colleagues at the University of Idaho. After a series of experiments, they concluded:

> If we come back to the question, "How much sediment (coarse sand and smaller) is too much?" we find that when the percentage of fine sediment exceeds 20 to 30 percent in spawning riffles, survival and emergence of salmonid embryos begins to decline. When riffles are fully imbedded with fine sediment, insect species composition, if not abundance, changes. The abundance of juvenile salmon in pools of small rearing streams declines in almost direct proportion to the amount of pool area or volume lost to fine sediment deposited in the pool. The number of juvenile salmon and trout a stream can support

in winter is much reduced when the interstices in the stream substrate are filled with fine sediment." (Bjornn, et al., 1977)

Our own investigations on small California coastal streams confirm this view. Yet the 30-35% maximum embeddedness in the Tucannon is small compared to that found on many streams and, compared to other problems on the Tucannon River, we do not believe it is of great significance.

Our investigations of dissolved oxygen concentrations and other conditions within the gravel of the streambed, led us to conclude that in the upper reaches of the river where water temperatures are suitable for rearing juvenile salmonids, there is normally no sedimentation of the substrate to a degree that would hamper egg hatching. Conditions in the middle section of the river are less optimum, and whether or not problems do occur there depends to a large extent upon the timing of storms following egg deposition. The suspended sediment is carried into the nest along with stream water. In the Tucannon from Marengo downstream to Pataha Creek, enough sediment may be deposited often enough to damage perhaps half the nests seriously - but many eggs would survive.

The picture in the lower Tucannon below Pataha Creek is quite different. There the streambed tends to be consolidated with a mixture of fine sediment and gravel, so that not only is redd building difficult, but later there is a large chance of enough sediment being deposited in the redd to cause the loss of eggs through dissolved oxygen deficiencies. Under present conditions, we would not expect significant amounts of successful reproduction.

This is not true for the very lower end of the river where gravel has been deposited near the reservoir. The gravels there are much looser and we found dissolved oxygen conditions in them to be satisfactory for egg incubation much of the time. This lower end is the site of spawning for a small fall run of chinooks which may be taking advantage of that particular situation.

Substrate in parts of the lower and middle portions of the river is easily moved during high flows--so that salmonid eggs buried in the substrate can be scoured away. This is not an unusual condition in salmon and steelhead streams but it is a difficult one to assess. The large losses of eggs that result may be more than compensated for by the large numbers of eggs deposited by each female. Our efforts to measure scour with buried Ping-Pong balls were largely unsuccessful in that most strings of balls disappeared. Some, particularly in the

upper stations remained in place. Some, in the middle reach, were buried and later recovered by digging, and some, especially below Pataha Creek, were never seen again. The experience suggested to us that scour of eggs from nests could well be a problem in the middle and lower river if there was spawning there.

The mobile substrate is, of course, related to the lack of pools. Those formed with a dam of resistent substrate down at their lower ends tend to be easily filled by migrating gravels and cobble during high flows.

HIGH STREAM VELOCITIES

In most of the upper reaches of the Tucannon River where water temperatures are cold enough to rear significant numbers of salmonids, high current velocities are the principal constraint to rearing additional salmonids. Dr. Li listed that as the principal constraint in 53% of the glides and 100% of the riffles, which together cover approximately 87% of the river's length from Bridge 14 to Sheep Creek. If the water temperature problem was solved in the middle and lower reaches of the Tucannon River, high velocities would become the principal constraint to better juvenile rearing habitat there. Dr. Li listed high velocities as the principal limitation on physical habitat in about 68% of the river from Bridge 14 downstream.

The commonness of the high velocity problem is illustrated also by the fact that 73, 60, and 59% of the length of the upper, middle, and lower river reaches, respectively, are composed of riffles. Only 2, 5, and 5%, respectively, are composed of pools. We consistently rated the rearing habitat quality in riffles on the Tucannon River only about one-third as good as in pools, and about half as good as in glides. Our measurements of fish populations indicate that those ratings are about directly proportional to the numbers of yearling steelhead that the stream could rear, and that the populations of chinook salmon would increase faster than the rearing index. This is primarily because juvenile chinooks were more sensitive to the constraint of higher velocities.

During our winter investigations, we were concerned that high velocities might also limit the available spawning area in the Tucannon River. At almost every station along the river, we had to search with some care to find water deep enough, with the proper gravel substrate, and where stream velocities were not above the 2 fps level that we set as a high, but still desirable, velocity for spawning. Such places

are limited to the lower ends of glides just before they break off into the riffle. While sites with proper combinations of depth, current velocity, and substrate are not abundant throughout the river, we have no evidence that they limit the number of adult salmon and steelhead that remain in the Tucannon River run. If the run were ever restored to its former size, high velocities for spawning could become a constraint.

The high velocities also tend to increase the mixing of water, making temperatures homogenous and allowing it to warm quickly.

THE LACK OF POOLS

Only 4% of the total length of the stream was pools during the summer of 1980. Pools are important to adult steelhead and chinook salmon here because both return to the river several months before spawning. They must find quiet, safe places to rest where they do not need to expend large amounts of their waning energy. This is particularly important for the salmon, who exist on a limited supply of stored fat, and who remain in the stream for several months waiting for water temperatures to drop so they can spawn in the fall. We saw no pools crowded with large numbers of adult fish waiting to spawn, but the runs are too low to expect that. The few adult fish we did observe during the summer were in pools, and if the runs were restored we expect that crowding of adults might become a problem.

The evidence is clearer, however, that lack of pools is a major constraint to the juvenile rearing habitat and probably to actual production in the upper river. Besides the higher ratings of habitat quality given pools during our survey, we noted that both salmon and steelhead juveniles taken from pools were consistently larger than those collected elsewhere. This is not surprising, since the slower current velocities in pools are less expensive physiologically to salmonids. The juvenile chinooks with their reduced territoriality would especially benefit by an increase in pools.

The lack of pools in the river may also have something to do with the low population of invertebrates that feed by shredding leaves and other large particulate organic matter. Pools trap such allochthonous detritus, giving it more time to break down and permitting more access to this food resource by aquatic invertebrates.

Finally, there isn't much question that an increased number of pools would tend to keep the stream cooler. Brown

(1972) found that large pools have a great influence on water temperatures.

Three long-term residents along the Tucannon River, Messrs. Delbert Howard, Emil Harvid, and Otto Krouse, all told us that years ago there were many pools along the river, and many were deep enough for a man to dive into or in which he could swim a horse. They said that most of these pools were formed by logjams or large boulders that were washed away in the floods of 1964-65.

We believe that a program aimed at creating more pools in the Tucannon River would greatly increase its quality and its potential to rear salminids. We calculated on the basis of the calibrated rearing indexes and the mean areas of both pools and riffles, that the creation of each pool similar to those that do exist in the upper river would increase its rearing capacity by about 50 yearling salmonids (table 28). Longer and larger pools would, of course, create more.

SALMONID FOOD PRODUCTION

This study developed evidence that there was no shortage of food for juvenile or adult salmonids in the Tucannon River. The density of standing populations of invertebrates in the summer and the early fall compares favorably with the higher densities found elsewhere and the growth rate of young salmonids is relatively high.

Table 28. Yearling salmonids that could be gained by building one pool on a riffle in the upper Tucannon River.

$$RI_{pool} = \frac{(6.74)(29.65)(44.07)}{44.07} = 199.84 \equiv 4.9$$

$$RI_{riffle} = \frac{(2.53)(29.65)(104.66)}{104.66} = 75.01 \equiv 1.57$$

$$\begin{array}{rcrl} 4.9 \times 44.07 & = & 215.94 & \text{salmonids in pool} \\ 1.57 \times 104.66 & = & -164.32 & \text{salmonids in riffle} \\ \hline & & 51.62 & \text{salmonids gained} \end{array}$$

CITATIONS

Aggus, L. R. and L. O. Warren. 1965. Bottom organisms of the Beaver Reservoir basin: a pre-impoundment study. J. Kansas Entom. Soc., 1965. 38(2):163-178.

Anderson, N. H. and James R. Sedell. 1979. Detritus processing by macroinvertebrates in stream ecosystems. Ann. Rev. Entomol. 1979. 24:351-377.

Armitage, Kenneth B. 1958. Ecology of the riffle insects of the Firehole River, Wyoming. Ecology, 1958. 39:571-580.

Basham, Larry and Lyle Gilbreath. 1978. Unusual occurrence of pink salmon (Oncorhynchus gorbuscha) in the Snake River of southeastern Washington. Northwest Science, Vol. 52, No. 1, 1978.

Bjornn, T. C., M. A. Brusven, M. P. Molnau, J. H. Milligan, R. A. Klamt, E. Chacho, and C. Schaye. 1977. Transport of granitic sediment in streams and its effects on insects and fish. Forest, Wildlife, and Range Experiment Station Bulletin No. 17: 43 pp.

Brown, George Wallace. 1972. An improved temperature prediction model for small streams. Water Resources Institute. URRI-16:1-20. Dept. of Forest Engineering, Oregon State University, Corvallis, Oregon.

Carlander, K.D. 1969. Handbook of Freshwater Fishery Biology. Iowa State University Press. 752 pp.

Coble, D. W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. AmFishSocTrans. 90:469-474.

Coleman, M. J. and H. B. N. Hynes. 1970. The vertical distribution of the invertebrate fauna in the bed of a stream. Limnology and Oceanography. 15(1):31-40.

Coutant, Charles C. 1970. Thermal resistance of adult coho (Oncorhynchus kisutch) and jack chinook (O. tshawytscha) salmon, and adult steelhead trout (Salmo gairdneri) from the Columbia River. Battelle Memorial Institute, Pacific Northwest Laboratories. BNWL-1508, UC-48. 24 pp.

Cummins, Kenneth W. 1974. Structure and Function of Stream Ecosystems. BioScience, 1974. 24(11):631-641.

Cummins, Kenneth W. 1973. Trophic relations of aquatic insects. Annual Review of Entomology, 1973. 18:183-206.

Davis, S. N. and R. J. M. DeWiest. 1966. Hydrology. John Wiley and Sons, Inc. New York. 463 pp.

Environmental Protection Agency. 1973. Methods for measuring the quality of surface waters and effluents. Environmental Monitoring Series. EPA-670/4-73-001.

Hart, Donald S. and Merlyn A. Brusven. 1976. Comparison of benthic insect communities in six small Idaho batholith streams. Melanderia, 1976. 23:39 pp.

Hayne, D. W. 1949. Two methods for estimating animal populations. J. Mammalogy 30:399-411.

Hynes, H. B. N. 1961. The invertebrate fauna of a Welsh mountain stream. Arch. Hydrobiol. 1961. 57:344-388.

Kennedy, H. D. 1967. Seasonal abundance of aquatic invertebrates and their utilization by hatchery reared rainbow trout. Tech. Papers Bur.Sport Fish. and Wildlife No. 12. 41 pp.

Lee, D. R. and J. A. Cherry. 1978. A field exercise on ground-water flow using seepage meters and minipiezometers. Jour.Geol.Educ. Vol. 27:6-10.

Lorenzen, C. J. 1967. Determination of chlorophyll and pheo-pigments: spectrophotometric equations. Limnol.and Oceanog. 12, 343-346.

Mackay, Rosemary J. and J. Kalff. 1969. Seasonal variation in standing crop and species diversity of insect communities in a small Quebec stream. Ecology, 1969. 50(1):101-109.

Maitland, P. S. 1966. Studies on Lock Lomond. II. The fauna of the River Endrick. Blackie and Son, Ltd., Glasgow. 194 pp.

Marker, A. F. H. 1976. The benthic algae of some streams in Southern England: I. Biomass of the epilithon in some small streams. J. Ecology, 1976. 64:343-358.

McConnell, William J. and W. F. Sigler. 1959. Chlorophyll and productivity in a mountain stream. Limn. and Oceanog. 1959. 4:335-351.

McIntire, C.David. 1966. Some effects of current velocity on periphyton communities in laboratory streams. Hydrobiologia, 1966. 27:559-570.

McNeil, W. J. 1962. Variations in the dissolved oxygen content of intragravel water in four spawning streams of southeastern Alaska. USF&WS, Spec.Sci.Rep. Fish No. 402. 15 pp.

Merritt, Richard W. and Kenneth W. Cummins (ed.) 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Publishing Co. 441 pp.

Minckley, W. L. 1963. The ecology of a spring stream, Doe Run, Meade County, Kentucky. Wildlife Monographs, 1963. 11:1-124.

Minshall, G. Wayne. 1981. Structure and temporal variations of the benthic macroinvertebrate community inhabiting Mink Creek, Idaho, USA, a third order Rocky Mountain stream. Jour. Freshwater Ecology, 1981. 1(1):13-26.

Minshall, G. Wayne. 1967. Role of allocthonous detritus in the trophic structure of a woodland springbrook community. Ecology, 1967. 48:139-149.

Nelson, Daniel J. and Donald C. Scott. 1962. Role of detritus in the productivity of a rock-outcrop community in a piedmont stream. Limn. and Oceanog. 1962. 7:396-413.

Pate, V. S. L.1932. Studies on fish food supply in selected areas. A biological survey of the Oswegatchie and Black River Systems. NY State Cons. Dept., Suppl. 21st Ann. Rep. pp 133-149.

Quigley, Thomas M. 1981. Estimating contribution of overstory vegetation to stream surface shade. Wildl.Soc.Bull. 9(1) 1981. pp 22-27.

Richards, F. A. and T. G. Thompson. 1952. The estimation and characterization of plankton populations by pigment analysis. II. A spectrophotometric method for the estimation of plankton pigments. J. Marine Res., 11:156-172.

Simons, Richard R. 1971. Tucannon River anadromous fish life history timing for use in coordinating hydraulic work. Memo for Washington Department of Game.

Stockley, C. 1980. Letter stating the condition of the salmon fishery on the Tucannon River with estimates of escapement and river catch. Letter sent to S. K. Li, dated July 10, 1980, from Washington Dept. Fisheries.

Surber, E. W. 1937. Rainbow trout and bottom fauna production in one mile of stream. TransAmerFishSoc. 1937. 66:193-202.

US Soil Conservation Service. 1973. Soil Survey of Columbia County Area, Washington. 88 pp.

Washington Departments of Fisheries and Game. 1961. Survey and proposed development report of the lower Snake River subbasin, Washington. 37 pp.

CITATIONS (cont.)

Weber, C. I. 1973. Recent developments in the measurement of the response of plankton and periphyton to changes in their environment. In Bioassay Techniques and Environmental Chemistry, (G. E. Glass, ED.) Ann Arbor, Michigan. pp 119-138.

Woodall, W. Robert, Jr., and J. Bruce Wallace. 1972. The benthic fauna in four small southern Appalachian streams. American Midland Naturalist, 1972. 88(2):393-407.

Wydoski, R. S. and R. R. Whitney. 1979. Inland Fishes of Washington. University of Washington Press. 220 pp.